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A survey of the uses of motion pictures in instrument flight

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A SURVEY OF THE USES OF MOTION PICTURES IN
INSTRUMENT FLIGHT

A Thesis
Presented to
the Faculty of the Department of Cinema
Institute of the Arts
The University of Southern California

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

---

by
William Emmett Stephens, Jr.
August 1951

Thesis
S695

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*under the guidance of h*is *Faculty Committee, and approved by all its members, has been presented to and accepted by the Council on Graduate Study and Research in partial fulfillment of the requirements for the degree of*

Master of Arts

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TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER I

I. STATEMENT OF THE PROBLEM AND DEFINITIONS OF TERMS

In recent years motion pictures have taken an increasingly important part in education while aviation has become increasingly complex and more dependent on instruments. The industry, the planes and instruction are all involved with instruments. More and more grows the need to fly safely through bad weather and conditions of no visibility. Such flights depend on instruments. Therefore, proper use of instruments implies proper and thorough training in their operation and solid acquaintance with their construction. Motion pictures can aid in teaching the use of instruments; they can study the need of instruments; they can record, and thus aid in evaluation of instruments.

Statement of the problem. The purpose of this study is: (1) To make a survey of the films used in teaching instrument flight; (2) to gather information on the research that was done on pilot eye movement and the uses of motion pictures in that aspect; (3) to determine the need of schools that teach instrument flight; (4) to approach new landing aids as a photogenic subject; and (5) to present the findings in a manner that will aid in making motion pictures that teach instrument flight.

Limitation of the study. The study is strictly limited to the subject of instrument flight. The great number of related subjects have been excluded to narrow the problem as much as possible without weakening the structure of the thesis. No attempt has been made to cover the numerous films on Aerology, Aerodynamics, Aircraft Maintenance, Radio Equipment, Visual Flight Instruction, and many others. Instrument flight involves the simultaneous solution of two problems: one of them is concerned with the manipulation of the aircraft, and the other is concerned with avigation of the craft in space.

> Proficiency in instrument flight, [however] requires:
>
> 1. an understanding of the relationship of control coordination and power to obtain the desired performance.
>
> 2. an understanding of the fundamentals of practical aerodynamics.
>
> 3. a thorough working knowledge of the flight instruments used to control flight attitude and their limitations.
>
> . . . .
>
> 5. a complete understanding of procedures connected with the use of radio aids to navigation and their application.[1]

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[1] Instrument Flight Procedures, U. S. Naval Schools, All Weather Flight (Corpus Christi, Texas: U. S. Naval Air Station, 1950), foreward, p. 3.

Status of the study. This survey is unique in that it is the first to be conducted solely on motion pictures that deal with instrument flight. The idea for the survey arose out of the author's need for information on instrument flight and also from the fact that other pilots who have not been actively engaged in regular flights need a source of ready instruction and information.

The survey was conducted during a period when the United States was rearming itself. Men who had not flown for some time wanted and needed refresher material in basic work. They needed information on newer systems of instrument flight. The military forces, in the expansion of their program of flight training at this period, indicated a need for films by having produced the first film on basic instrument flight.

Importance of the study. Fields of aviation and motion pictures are comparatively new. Each in itself is growing in importance. Aviation is now recognized to be the mode of travel that delivers the best and the fastest. Our modern way of life grows increasingly dependent on speed and quality of that speed. The protection of our way of life is developed on our airpower. The need for protection, the demands of commerce, and the emergencies of sickness emphasize the want to fly safely all day and night

every day. Motion pictures are important in finding that way and satisfying that want.

<u>Method of procedure</u>. An attempt was made to contact the flight schools in the immediate area to determine what was available as motion picture training aids on the problem. Further, determine what problems these schools had, if any. Flights were made to the All Weather Flight School of the U. S. Navy in Corpus Christi, Texas, to investigate the situation there. The Navy had been working for some time to complete a motion picture that would be used in the All Weather Flight School.

Studies that had been done on instruments and their placement in the airplanes were investigated, films were viewed, and the author attempted to renew his own instrument qualifications with the aim of determining what help training films would be.

<u>Statement of the sources of data</u>. Flying on instruments is a skill that must be developed. It requires proper equipment and training. It also implies a need to fly in bad weather for this type of flying is not something that is done for pleasure. The very nature of instrument flight limits it to the military forces and scheduled air lines that endeavor to maintain constant flight schedules.

This survey was made of the local air lines to

determine what films were used in their pilot training program. The chief pilots of the local air lines were contacted, either in person or by letter, and questioned about the films their companies used. The survey continued to the military forces. It was discovered that the Air Force and the Naval air arm interchanged films freely. Since the author is a naval aviator, the investigation was concentrated on naval bases. All pertinent films from the libraries of the Naval Air Station, San Diego, California; N.A.S., Alameda, California; N.A.S., Los Alamitos, California; and the Army film library of this district were viewed. In addition, several trips were made to the Navy's All Weather Flight School in Corpus Christi, Texas, to gather information and to view films.

Letters were written to various manufacturers of instruments and to various organizations that were concerned with aviation and photography to determine what use they made of motion pictures.

II. DEFINITIONS OF TERMS USED

Avigation. Method or means whereby the position of an aircraft is determined without visual reference to the surface of the earth, and guides the craft along a desired path.

Instrument flight. Instrument flight is a method of safely conducting cargo or passenger aircraft by means of dials, pressure gauges, and gyroscopic instruments when weather conditions obscure normal means of orientation.

Orientation. Orientation is a knowledge of one's position normally arrived at through visual contact with the earth and a sense of balance.

Radio navigation. The means of conducting the flight of an aircraft between two points by the guidance of radio signals.

III. ORGANIZATION OF THE REMAINDER OF THE THESIS

The second chapter is concerned with training films on instrument flight. The following chapter contains a very brief review of the methods of studying eye movements used by psychologists. The fourth chapter deals with avigation training films. The fifth chapter was written on films dealing with confidence. Chapter VI concerns itself with new aids to instrument flight. Chapter VII is the summary.

CHAPTER II

TRAINING FILMS ON INSTRUMENT FLIGHT

The purpose of this chapter is to present the findings of the survey that was made of instrument training films. The work done on this portion of the thesis consisted of: (1) viewing every available film that mentioned the words "flight instrument" or "weather flight" or in any way indicated that the subject was concerned with information on this problem; (2) contacting the local commercial airlines to determine what films, if any, were used in their flight schools; (3) writing to the manufacturers of aircraft instruments and to various departments of the government to determine if any films, or training aids were being contemplated; and (4) visits to various aircraft manufacturers in the local area to see the films that were being made of their particular planes.

Method of survey. This investigation began with a search through film catalogues of the Civil Aeronautics Administration, Naval Air Stations, and the U. S. Army Film Library to determine what films on this subject were available. This work has not, however, used any material that the military forces considered classified. Only those films marked "unclassified" were viewed.

The first point of search was the branch film library

of the Civil Aeronautics Administration located here in Los Angeles. Every film available on the subject was viewed. From that point the unclassified films at the Naval Air Station, Los Alamitos, California, were viewed. The author then contacted the chief pilots of the largest airlines in the vicinity of Los Angeles. This city is the center of operation for several first line air carriers that would act as a cross-section for the training of commercial pilots.

After the interviews had been completed, the search to find films was taken up again. Trips were made to San Diego, California; San Francisco, California; and to Corpus Christi, Texas; to view films available. In all of the above-named cities the U. S. Navy maintains film libraries. Also, in Corpus Christi, the Navy operates an All Weather Flight School to train its Naval aviators to fly through instrument weather conditions.

In between the interviews and the search for films, letters were written to manufacturers of flight instruments and to the various departments of the government to determine what material was available. Along with this, books and manuals on the subject were read to determine the possibility of presenting the material in a motion picture.

Results. The results of the entire survey were generally very slim. There were no films in circulation on

the subject of flight on instruments. It was learned, however, that the Navy had become interested in a training film on the subject and had completed one film, but as yet had not distributed the film. Several films on radio navigation were found. These will be considered in another chapter. Other films on operation and maintenance of various types of instruments were in evidence. Several good films on weather, aerodynamics, and other related material were available. Those subjects were not the object of this thesis and were not considered.

The cross-section of the six film libraries (C.A.A., Los Alamitos, San Diego, San Francisco, Corpus Christi, and the Sixth Army Library) is considered good because they generally carried the same films.

Ninety-three films were viewed either in part or totally. Films were viewed for both subject matter and technique of presentation. Several of them were not related to instrument flight, but they were of interest because of the manner of presentation of their particular subject. Of this group of films the date on the latest was 1949. The earliest was 1942. The majority were made between 1943 and 1945.

All of the films were made by the U. S. Government. The majority by far were made under the sponsorship of either the Air Force or the Navy, a limited number were made

for the Civil Aeronautics Administration. No attempt has been made here to separate the films made by these various departments for it was found that unification did exist, at least in the film distribution, and that the three departments exchanged films freely.

Of all the films viewed only one related to the subject of this chapter, namely, instrument flight. It is well at this point to bring to mind again the meaning of "instrument flight". This is the actual control of the plane by means of reference to dials, gauges, and indicators that register in a manner that will enable a man, through his interpretation of their registration, to safely conduct his craft. This is important for unless the act of flying on instruments is well learned and performed it is impossible to travel between two points and to land once a destination is reached.

This one film mentioned was produced by the Navy. Titled "Flight Through Instruments", it was made by Polaris Pictures, Inc., of Los Angeles, California. The script was prepared under the supervision of the U. S. Naval School/ All Weather, at the Naval Air Station, Corpus Christi, Texas. The All Weather Flight School requested that the film be made as an aid in their ground school work. The purpose of the school is to qualify Naval Aviators as instrument pilots. The students have had a good deal of

flight experience, but have lacked the qualifications required to fly on instruments. The All Weather School felt that there was a need for a film on basic instrument flight.

The purpose of the film "Flight Through Instruments", was to: (1) review and refresh instrument technique; (2) emphasize proper scanning, which is a method of sequence of reading the instruments; (3) accentuate the fact that the basic purpose of all weather training was safety in flight; (4) serve as a review of basic material related to instrument flight; and (5) emphasize flight by attitude. It also briefly explains vertigo which is a state of confusion caused by the loss of familiar references, and false sensations. It went just as briefly into attitude, or position flight then quickly swung into aerodynamics and into the need for understanding instrument construction. The remainder of the picture went quickly into power reactions of the plane when throttle was added or reduced, and into various maneuvers such as timed turns, partial panel work, full panel work, illustrations of how a pilot could fall into dangerous flight attitudes, and emphasized the need for proper scanning methods.

It is very easy to see that the above is a lot of material to include in one motion picture that runs for only thirty minutes. Therein lies, perhaps, one reason why, before this picture, there were no films on instrument

flight as such. The subject is deeply involved with related material.

Interviews with air lines. The chief pilots of every air line at the Los Angeles Municipal Airport were contacted and questioned about the films used by the flight school of his company. In cases where there was doubt, the school, if it existed in another locale, was written. The air lines were

(1) American Air Lines

(2) Pan American World Airways

(3) Transworld Air Lines

(4) United Air Lines

(5) Western Air Lines

Not a single one of the above companies had films on instrument flight. They all used the films that the military forces made on aerology. Two of the companies professed knowledge of the films on Flight Procedures, but did not use them. All of the companies stated that their pilots were expected to have instrument flight qualifications before they were hired and were expected to maintain those qualifications through actual time in the cockpit.

One of the chief pilots thought films could be made on the subject and would be useful.

Two of the chief pilots expressed doubt of the

usefulness of training films. Their belief was that a man learned to fly only in the cockpit of a plane.

One had no opinion at all.

Another, by letter, commented on the use of slides, wall chart, cutaway parts and working models of operating units, but failed to express a concrete opinion on the use of training films.

Letters and personal visits. Seventeen letters were written to: (1) prominent manufacturers of flight instruments; (2) departments of the Air Force; (3) departments of the Navy; (4) organizations that deal with flight safety. Visits were made to local aircraft manufacturers and to the Institute of Aeronautical Science.

The letters asking for information on the uses of motion pictures in the study of flight instruments and in the teaching of instrument flight were written to the below listed sources.

I. Manufacturers:

(1) Airborne Instrument Laboratory,
Mineola, New York

(2) Bendix Aviation Corporation,
Red Bank, New Jersey

(3) Eastman Kodak Company, Industrial Division,
Rochester, New York

(4) Eclipse-Pioneer, Division of Bendix Aviation
Corporation, Teteboro, New Jersey.

(5) Engineering and Research Corporation,
Hyattsville, Maryland.

(6) Sperry Gyroscope Company,
Great Neck, Long Island, New York

(7) Ganisco Products,
Los Angeles, California

II. Organizations:

(1) Flight Safety Foundation, Inc.,
New York, New York

(2) Spartan School of Aeronautics,
Tulsa, Oklahoma

(3) Dr. Morris S. Viteles, Department of
Psychology, University of Pennsylvania,
Philadelphia, Pennsylvania

III. Departments of the Government:

(1) Department of Commerce,
Civil Aeronautics Administration,
Washington, D. C.

(2) Department of Commerce,
Civil Aeronautics Administration,
Technical Development,
Indianapolis 21, Indiana

(3) Director of Flight Safety Research,
Norton Air Force Base,
San Bernardino, California

(4) U. S. Naval Air Development Center,
Johnsville, Pennsylvania

(5) Naval Air Materiel Center,
Philadelphia, Pennsylvania

(6) Air Materiel Command, U. S. Air Force Base,
Wright-Patterson Field,
Dayton, Ohio

IV. Personal Visits:

(1) Office of Naval Research,

Los Angeles, California

(2) Douglas Air Craft Company,
El Segundo, California

(3) Douglas Air Craft Company,
Santa Monica, California

(4) North American Air Craft,
El Segundo, California

(5) Institute of Aeronautical Science
Los Angeles, California

(6) Sperry Gyroscope Company,
Los Angeles, California.

At this point it is worth while noting that in these times of world unrest and nervous activities, busy men could find time to answer the queries of a student.

The answers to the letters and questions were generally negative. However, three of the letters produced fruit. The letter from the U. S. Naval Development Center recommended a number of references that contributed heavily to Chapter III. The letter from the Naval Air Materiel Center produced evidence that there was a film on the subject of "Pilot Eye Fixation". Again this was support for Chapter III, and for this thesis.

The Sperry Gyroscope Company, through the letter from their office in Great Neck, New York, and through their branch office in Los Angeles, provided both information and films. The letter from Mr. H. C. Bostwick is quoted, in part, below:

1. In reply to your letter of January 17, 1951, concerning our use of motion pictures in our flight test work, we have found them useful in two major respects. The first is as an educational medium. In this case movies are made showing the functional and operational usage of certain flight instruments. Although this medium has been beneficial, it is believed that the principal functions played by motion pictures, as far as our operations are concerned, is in the collection of flight test data. Here we have used a movie camera to record a wide variety of instruments. We also have taken movies of approaches made under conditions of extremely low ceiling and visibility.

2. In the latter case, motion pictures appear to be the only method of recording which gives the viewer a "feel" of what these approaches look like to the pilot.

3. It is our intention to continue taking these data movies for an indefinite period. . . .[1]

The Sperry office in Los Angeles furnished copies of two of their pictures which will be discussed in Chapter IV. These pictures, "The Zero Reader" and "The Gyrosyn Compass", were produced to demonstrate Sperry instruments. This company also produced a film, "The Attitude Gyro Indicator", for the military forces. This film will also be discussed in Chapter IV.

<u>Visits to aircraft companies</u>. The visits to aircraft manufacturers shattered an old mental picture of how instrument flight test data were recorded. It was believed that cameras were mounted in the cockpit all around the

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[1] Personal letter from H. C. Bostwick, Engineering Director for Flight Research, Sperry Gyroscope Company, Great Neck, New York, January 29, 1951.

pilot in a plane to be tested. Perhaps at one time such a set up was used, but present day collection on instrument flight test data is done differently.

The flight test section of the Douglas Aircraft Company, at El Segundo and in Santa Monica, demonstrated their set up for compiling data. The same arrangement was used in the smaller plane made at El Segundo and in the larger four engine plane made at Santa Monica and Long Beach. An enclosed-open-top-box arrangement was used. The instruments were stationed in one side of the box and a camera was mounted in the same side with the instruments. Directly across from the instruments and camera lens, two feet away, was a mirror. Along each side of the mirror a series of small lamps were placed so as to strike the instrument panel at a forty-five degree angle. Thus, the panel was lighted. The camera and lights were controlled electrically from the cockpit and were set in motion when desired. In this manner, the camera, in photographing the mirror, effectively doubled the distance between the lens and the panel. This unit is very compact and easily moved. Any instrument, engine or flight, of standard size could be installed in the panel. The camera was a 35mm DeVry which had been altered by Douglas to fit the test stand. See Figure I.

The results on the film were read by means of a

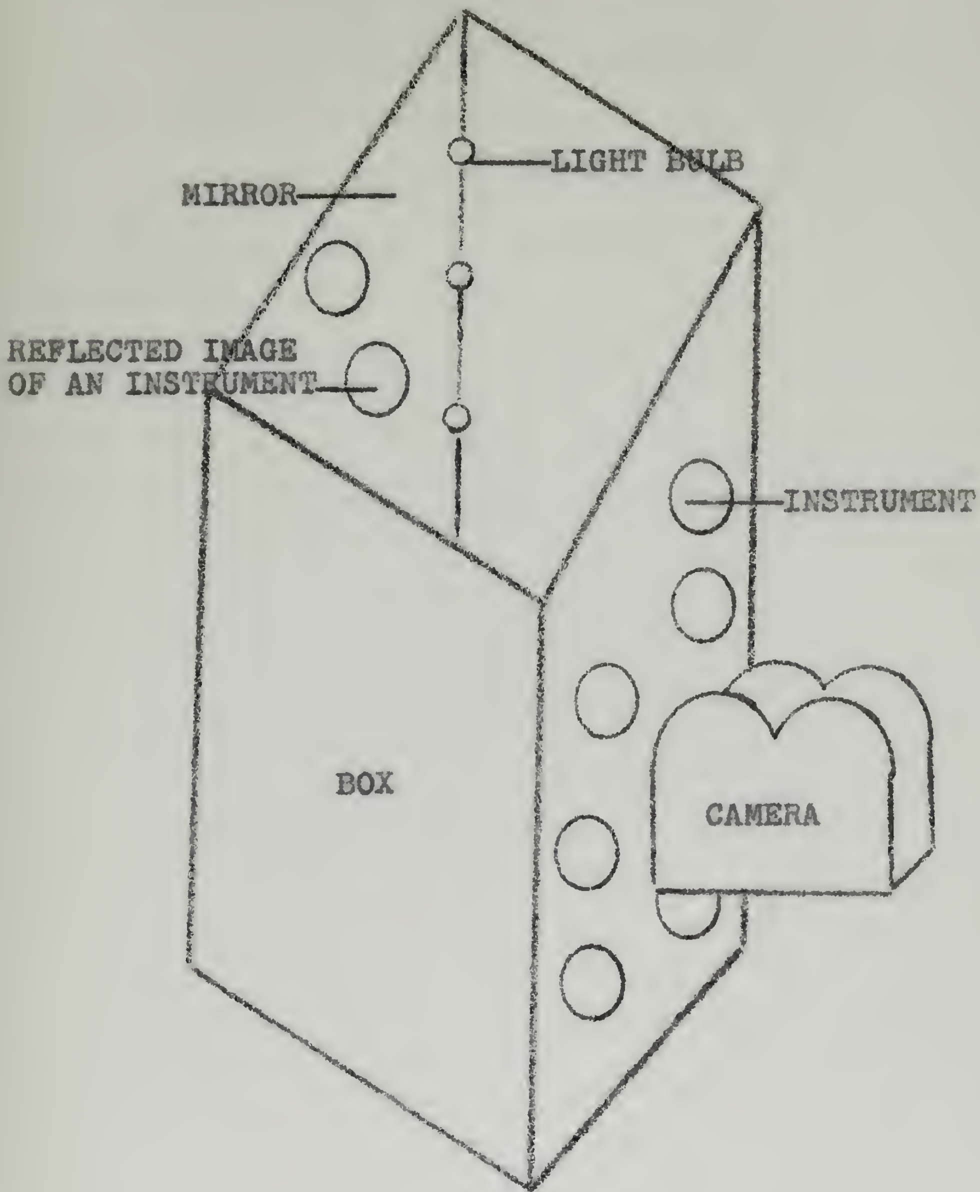

FIGURE I

AN ENCLOSED-OPEN-TOP-BOX FLIGHT TEST DATA STAND

"Recordak Library Film Reader" made by Eastman Kodak Company. The data were compiled in tables or on data curves. This arrangement is interesting as a means of evaluating flight instruments.

CHAPTER III

EYE MOVEMENT STUDIES

This chapter is concerned with the role that motion pictures have played in the studies of pilot eye fixation. The growing complexity of modern aircraft and the errors that this situation causes emphasizes the need for simplification. The purpose of eye studies is to provide the basic data regarding pilot eye movement during instrument flight. Such studies provide material that is used in designing aircraft instruments and instrument panels on which many instruments are arranged.

Studies of this type are of interest to the psychologist because human beings are one of the links in the system of aircraft flight. So though the actual design of equipment is a problem of the engineer, the acceptability and the use of the design is a problem of the psychologist.

Motion pictures come into play because of the conditions under which the studies of the psychologists must be made. In studying and recording eye movement during instrument flight it was necessary that the pilot be as unrestricted as possible. The usual methods of eye study that require a fixed position of the head were undesirable and unsuited.

Development of the methods for observing and

recording eye movement. The intention here is to briefly review the different methods of studying eye movement before motion pictures were employed; and thus show the impossibility of their use as a means of studying the eye movement of aircraft pilots. The reading of flight instruments has been accepted as similar to normal reading.

There has been an increase in the study of eye movement since the third quarter of the last century. Attempts were made at that time to measure the speed of movement of the eye. The procedure was to divide the total time consumed by the eye moving back and forth between two points by the number of moves. Large errors were involved because account was not taken of the duration of the pause at the extreme ends. The Lamansky after-image method that was used in 1869 was an improvement. A pencil of light was flashed into the eye at regular intervals as the eye moved through a given arc. The speed of the eye sweep was determined from the number of after-images of light observable following a given sweep of the glance, and from a knowledge of the number of flashes per second. The number of flashes seen would be in direct ratio to the time taken for the movement.

The use of a mirror was not introduced until 1879, which was after several involved methods of eye studies had been used. Today it is common knowledge that the eye, during reading, moves by jerks or saccades, rather than in a

continuous sweep during the process of reading. E. Javal, a French ophthalmologist, was the first to note this. He also is recognized as the first man to begin psychological studies of the eye. In 1879 he reported a study in which he placed a mirror in front of a reader and counted the number of pauses per line. The mirror was placed in front and a little to the right of the reader so the investigator could place himself behind and observe the movement of the eyes during reading.

The mirror observation method continued in use, as was indicated by reports, as late as 1898. Studies were made of eye movement in reading native and foreign languages, and in reading proof.

Several mechanical arrangements had been devised. In France, Lamare, in his work with Javal counted the movement of the eyes by pressing a finger tip on the upper lid of a closed eye while the other eye was reading. Later, he attached a small microphone to the upper lid so that the sounds made by the movement of the eye could be heard and counted. In this manner he was able to count the number of pauses made during a line of print. This method was used to compare the number of eye movements when the same size text was read at different distances from the eyes.

A. Ahrens was interested in eye movements which occurred during writing. His studies were dated 1891. He

attached a small ivory cup to the cornea of the eye. A pointer was fastened to the cup so that it magnified the eye movements. The end of the pointer touched a smoked surface and thus traced the action of the eye. His idea obtained no successful records, but it did give rise to new ideas of new development.

The American Journal of Psychology, in 1898, reported that E. B. Delabarre made attempts along the lines that Ahrens worked and achieved greater success. He attached a plaster cup to a cocanized eye and tried to photograph a light beam that was reflected from a mirror held by the cup. He was not totally successful, however. He also cast a fine wire loop in the cup and connected this with a recording lever by means of a thread. A rubber band held the system in balance so that the horizontal movements of the eye were recorded on the smoked surface of a kymograph cylinder. This did not give satisfactory results either.

E. B. Huey at Clark University, in 1898, succeeded in completing a cup type recorder of eye movement. He constructed a cup from plaster of paris, molded it to fit the eye and had a small hole in its center to admit light to the eye. A light weight lever attached to the cup acted on an aluminum pointer, and recorded movement on a smoked drum.

All the mechanical methods were limited in their use and they also required very careful handling so that they

would not injure the eye or impose unusual loads that would cause inaccurate results. R. Dodge and T. S. Cline, in 1901 laid down certain conditions that a satisfactory study must fulfill.

> The eye must operate normally, the apparatus must be capable of registering both eyes simultaneously; the unit of measurement must be very small; the registering medium must have neither momentum nor inertia, and the eyes must work under practically normal conditions; the apparatus should be such that records can be made from a large number of eyes without serious inconveniences to the subject either during or after the experiments.[1]

These requirements immediately suggest the use of photography. Dodge developed a method of photographing eye movement in 1901.

> The method consisted of directing a pencil of light at the eye and photographing the image of this which was reflected into the camera from the surface of the cornea. The camera was equipped with a falling plate arrangement. A steady fall of the plate at a constant velocity was achieved by the escape of compressed air, and later of oil, from a cylinder in which a piston moved. The speed of the fall could be varied by regulating the escape of air or of oil. A pendulum which oscillated within the plate box in such a way as to cut off at regular intervals the light coming in through the camera slit provided a timing device.[2]

C. H. Judd, at Yale, used a motion picture technique just prior to 1905.

He attached a small flake of Chinese white to the

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[1] Miles A. Tinker, "A Photographic Study of Eye Movements in Reading Formulae," Genetic Psychology Monograms, 3:81, February, 1928.

[2] Ibid., p. 82.

cornea and used that as a reference in eye movement and a bright metal bead on the rim of a spectacle frame worn by the reader as a point of reference in head movement. Successive kinetoscopic pictures were taken of the subject's face including the region of the eyes while he read. A mechanical drive maintained constant speed of the apparatus during exposures. A continuous record of the eye was obtained by having two films side by side. When one film was covered, the other was exposed. Movement of the eye in any direction was shown on the records. The path of the eye movement could be plotted accurately by projecting an enlarged image of the film on a drawing board, and outlining the successive positions of the spots of Chinese white. Time of fixation was obtained by relating this record to the time record which came from a device connected to the crank of the apparatus.[3]

This method was not generally used because of the lengthy and difficult plotting system.

In 1912 H. Ohrwall made a quantitative study of eye movement during subjectively steady fixation by watching the eye through a microscope. F. N. Freeman, during 1916, devised a headgear for holding a small mirror in position so an experimenter could observe movements of a reader's eye. W. R. Miles constructed a modification of Freeman's apparatus, and also devised a method for direct observation of the reader's eye movement. The direct method made use of a hole cut near the center of the copy. This permitted close up direct observation of the eyes and the reader was not so distracted as by the presence of a mirror.[4]

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[3] Ibid., p. 84.

[4] Ibid., p. 76.

Attempts were also made in 1913 to record movement by means of a pneumatic arrangement. A small distended rubber capsule was mounted on a spectacle frame so that it rested on the slightly drooping upper lid at the edge of the cornea. The capsule was connected to a small delicately adjusted tambour by means of a small rubber tube. Eye movement was recorded on smoked paper.

In 1921, R. Dodge contrived a mirror recorder for photographing eye movements. An adjustable frame that resembled a spectacle frame was held lightly to the head by various supports. A recording mirror was held gently against the closed lids of each eye directly opposite the apex of the cornea. Any movement of the eyes produced a change in adjustment of each mirror so that the reflected light was altered. The reflected light from each mirror passed through a slit in the camera to strike the film or plate.

Since Dodge in 1901 started the corneal reflection method of eye photography, many cameras have been built. The first cameras recorded only the horizontal motion of one eye. Dearborn made recordings of the vertical movement of one eye on a horizontally moving film and the horizontal movements of the other eye on a vertically moving film. The Iowa Eye Movement Camera employed the corneal reflection and obtained binocular records of both vertical and horizontal

movements.[5]

In the spring of 1942, Ross A. MacFarland, Ph.D.; Alfred H. Holway, Ph.D.; and Leo M. Hurvich, Ph.D.; completed a study that was started in 1940. Their research started out as an attempt to analyze visual processes into physiological and anatomical components, but ended as a study of functional relations.[6] In this study, the researchers used several photographic means of recording results. All of their instruments required fixed head positions and other impediments that ruled them out as a means of recording eye movements of aircraft pilots. Many of the later studies merely mentioned the use of photography to record, and failed to describe the equipment used.

The discussion of eye study methods was given to show the long background of the subject. It also substantiates the fact that for studies in confined spaces, like airplanes, a simple accurate method must be used. Of course, this leads to motion pictures.

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[5] Herbert H. Jasper and Robert Y. Walker, "The Iowa Eye Movement Camera," Science, 74:291, September 18, 1931.

[6] Ross A. MacFarland, Alfred H. Holway, and Leo M. Hurvich, Studies of Visual Fatigue (Graduate School of Business Administration. Boston, Massachusetts: Harvard University, April, 1942), 255 pp.

Items of eye movement measurement. Eye movement is influenced by a variety of factors. Purpose, difficulty, interest, all affect eye action. Eye movement during instrument flight should produce the same action that normal print does. Usually clear understanding and rapid assimilation produces few fixations and regressions, while ineffective perception and confused apprehension causes frequent fixation and regression. The length of fixation should vary considerably depending on the difficulty of the instrument reading.

The eye has been the object of much study for some time. Needless to say, all the items of interest and measurement are too numerous to mention. Those included herein are related to this particular study.

The fixation pause: The normal movement of the eye is quick and jerky. It moves from detail, or subject quickly and pauses, or fixes. It is during these fixation pauses that the eye actually sees. However, the eye is capable of forming an image if it slowly and smoothly follows an object. Arnold and Tinker reported that an average fixation pause of 0.157 seconds is required to identify a letter, after the eyes have made a twelve degree movement. In reading the mean pause duration varies about 0.2 to 0.4 seconds. Fixation pauses in reading probably are longer than those made in discrimination of sample

objects because more time is required for comprehension and assimilation of the meaning of material that is read than is required for mere discrimination. Pause duration increases as the difficulty of reading material increases.[7]

Regressive eye movement: This is the pause following a backward eye movement within a line of print. It is a factor that differs greatly in individuals and for different levels of reading matter.[8]

Fixation span: This is the number of words, or length of material that a person can read at one fixation of the eyes.[9]

Eye movement time: The time the eyes require between fixations. The time consumed has been measured to a mean of about seven per cent of total reading time.[10]

Description of motion picture equipment. The photographic equipment, in itself, that was used in recording eye

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[7] Captain Richard E. Jones, First Lieutenant John L. Milton, and Paul M. Fitts, Ph.D., Eye Fixations of Aircraft Pilots, I, A Review of Prior Eye Movement Studies and A Description of a Technique for Recording the Frequency, Duration and Sequence of Eye Fixations During Instrument Flight (U. S. Air Force Technical Report No. 5837. Dayton, Ohio: U. S. Air Force Air Materiel Command, Wright-Patterson Air Force Base, September, 1949), p. 2.

[8] Ibid., p. 3.

[9] Loc. cit.

[10] Loc. cit.

movement was not unusual or altered. Cameras have, for some time, been used as a means of making records and are becoming even more widespread in use. Regardless of the use, the camera remains basically the same. However, positioning the camera, or making material available to the camera, or conditioning results so they will be photogenic, is a problem.

In these studies of pilot eye movement the recording medium had to be such that would not incapacitate the pilot in any way. His eyes necessarily could not have been encumbered with apparatus or light beams, nor could his head be fixed in one position.

The United States Air Force Air Materiel Command at Wright-Patterson Air Force Base, Dayton, Ohio, conducted studies on four phases of instrument flight. In all four phases of the instrument flights, conditions were maintained as closely to the actual as possible. No artificial restrictions were imposed that might change the nature of eye movement or interfere with his control of the aircraft. Freedom of head motion was necessary and rendered impractical most of the standard eye movement recording instruments that employed a beam of light reflected from the cornea of the eye. Head movement also made impractical the use of electrical recording of muscle action potentials or of retina polarity. It was also desirable that the system used

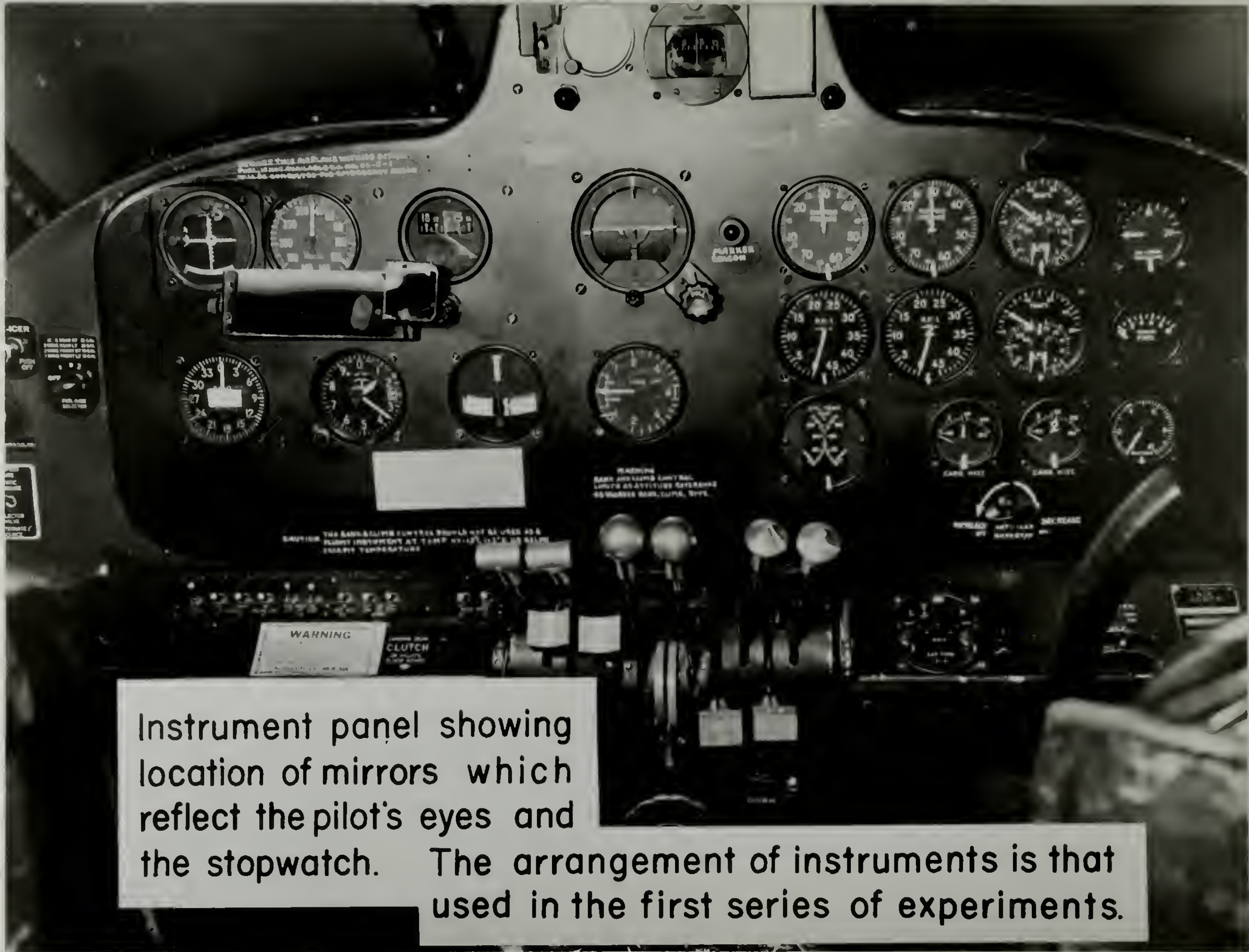
permitted relatively long periods of recording.

The equipment used consisted of a 35mm motion picture camera with a f8 lens, 400-foot film magazine, a small mirror (approximately 1¼ by 5½ inches) mounted on the instrument panel and a blind flying hood that restricted the pilot's vision to his instrument panel, and a stop watch which was photographed in the same frames that showed the position of the eyes. The mirror was mounted on the instrument panel, approximately in the middle of the flight group midway between the top and bottom rows of instruments. The mirror would be adjusted until the pilot's eyes reflected into the camera. See Figures II and III. All of the photographs in this chapter were obtained through the generosity of Captain Jones, Lieutenant Milton and Dr. Fitts, of the U. S. Air Force Air Materiel Command.

Vibration, a major problem in mounting the camera, was overcome by using a conventional wooden tripod secured to the deck of the craft by a quick release mechanism. See Figure IV.

There was a need to both limit the pilot's vision to his instrument panel and permit as much light into the cockpit as possible. A solution to this problem was arrived at by construction of a hood for the pilot and leaving the windshield unobstructed. The hood resembled a welder's shield and consisted of a sheet of sand blasted plexiglass

FIGURE II



Instrument panel showing location of mirrors which reflect the pilot's eyes and the stopwatch. The arrangement of instruments is that used in the first series of experiments.

FIGURE III


Conventional wood
tripod with quick-
release tie down
modification.
CAMERA MOUNTING
ARRANGEMENT USED
IN THE AIRCRAFT

FIGURE IV

fixed to a harness. This arrangement restricted the pilot, but permitted total vision for the safety pilot and unobstructed light for the camera.

The stop watch was mounted near the pilot's head at the same distance from the camera. A mirror was used to reflect the face of the watch so that each photograph of the eyes contained the watch also. This made it possible to determine to the nearest tenth of a second the interval covered by any period of photography and to calculate a time value for each frame.[11] See Figure V.

Procedure for analyzing the film records. The time on the stop watch was noted at the beginning and end of the film strip. The total elapsed time for one strip was determined and divided by the number of frames in the strip. Each frame was thus evaluated as to time. Each frame was then viewed on a moviola. The position of the eyes indicated the instrument being read. Reference photography had been made of each pilot looking at each instrument. The film scorer counted the number of frames spent on each instrument and computed the time per fixation. Eye blinks were also recorded, though most of them occurred between the

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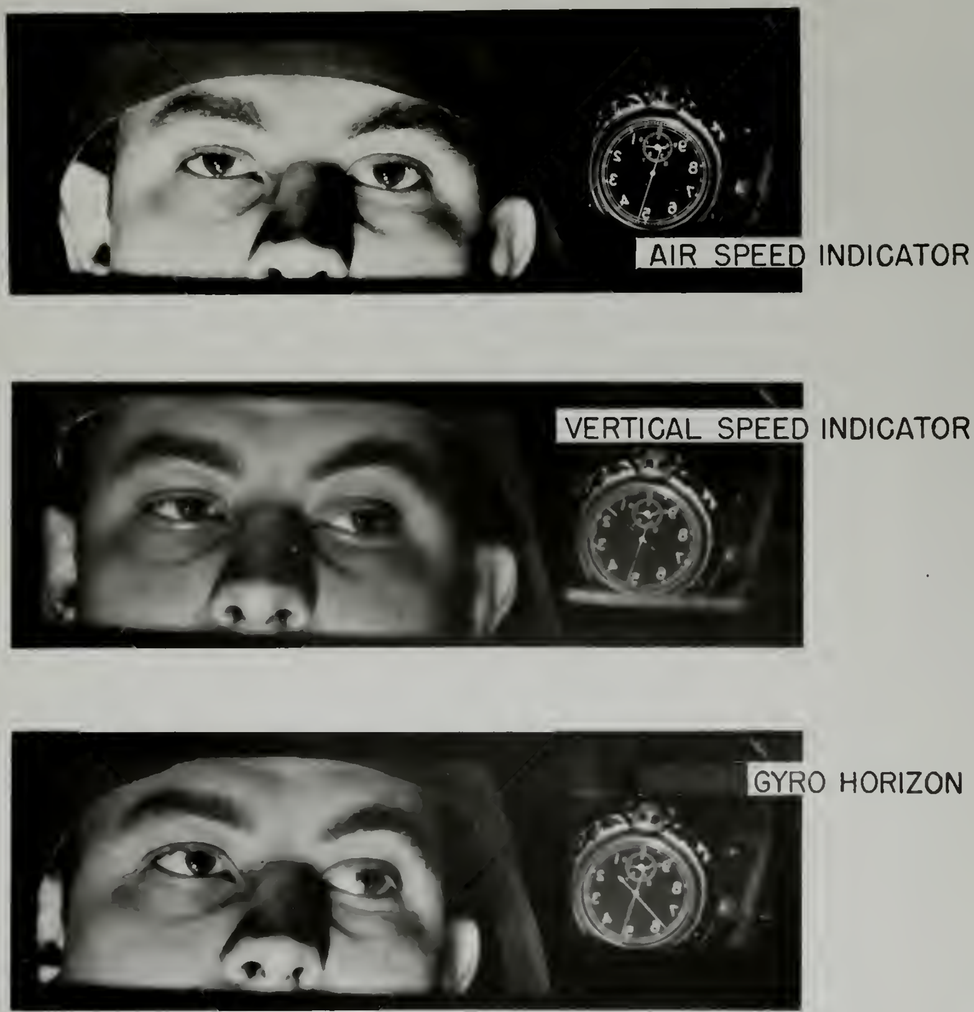
[11] _Ibid_., p. 15.



Three frames of photography reproduced from the film recording of one subject's eye movements to illustrate the ease with which the instrument the pilot is fixating can be determined.

FIGURE V

instruments.[12]

Camera speed of eight frames per second was selected because it was not considered likely that eye fixation of less than 1/8 second would occur. All fixations that could not be assigned to one instrument were classified in a miscellaneous category that included eye blinks.[13]

The films were read by two people on an individual basis. The two scores were compared and all differences were then studied together to determine a solution. After reexamination the film was discarded if there were not at least ninety-five per cent agreement.[14]

The analysis procedure was considered reliable because of the percentage of frames of film that were read identically by two independent scores. On one study, which used over forty thousand frames, ninety-one per cent of the total was read identically by two different scorers.[15]

Examples of studies made. As late as August, 1950, four studies were made of aircraft pilot eye fixation. In all four studies motion pictures were used as a method of

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[12] Ibid., p. 19.

[13] Loc. cit.

[14] Loc. cit.

[15] Loc. cit.

determining the desired values of time and pattern of eye movement. The studies were made on maneuvers that are vital to aviation, namely:

(1) Instrument Low Approach Systems (ILAS)

(2) Ground Control Approach (GCA)

(3) Routine Instrument flight

(4) Flying selected maneuvers

The purpose of the studies was to determine

(1) how pilots used their eyes while flying on instruments

(2) how often each instrument is checked

(3) how much time is required to check each instrument

(4) during critical maneuvers, what percentage of time is spent in seeking information from each of the different instruments.

(5) how are the frequency and duration of eye fixation influenced by factors such as pilot experience, instrument arrangement, instrument lighting and the manner being flown.[16]

See Figure VI.

The Air Force later made a film that depicted the results achieved in their studies. The film, for the

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[16] Captain Richard E. Jones, First Lieutenant John L. Milton, and Paul M. Fitts, Ph.D., Eye Fixations of Aircraft Pilots, II, Frequency, Duration and Sequence of Fixations when Flying the USAF Instrument Low Approach System (ILAS) (U. S. Air Force Technical Report No. 5839. Dayton, Ohio: U. S. Air Force Air Materiel Command, Wright-Patterson Air Force Base, October, 1949), p. 1.

LENGTH OF EYE FIXATIONS AND NUMBER OF FIXATIONS ON AIR-CRAFT INSTRUMENTS DURING G.C.A. APPROACHES

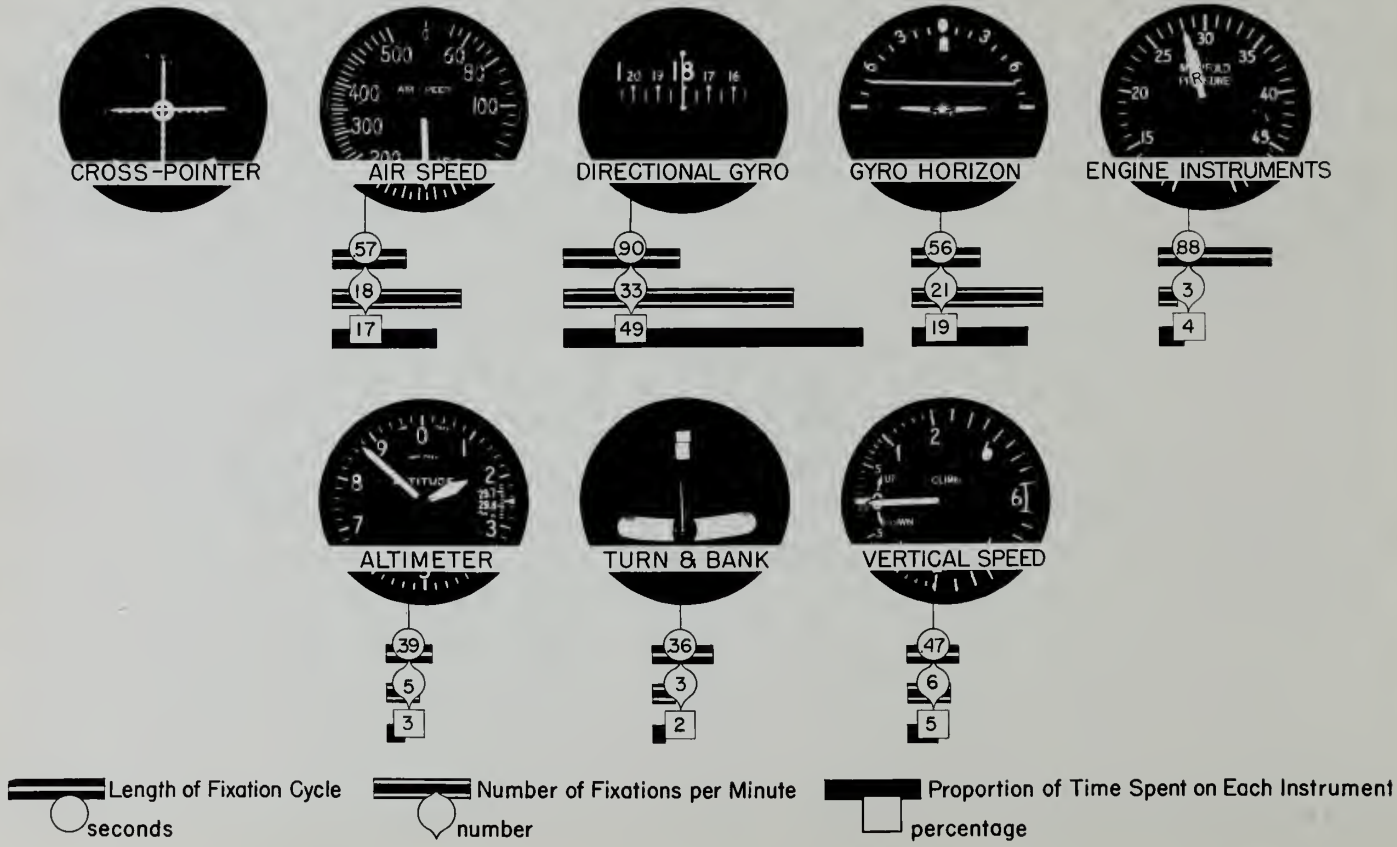

FIGURE VI

greater part, consisted of the same material that was presented in the reports that were written on the studies. However, the picture could illustrate the procedure and the equipment used and did include a section of the actual recording.[17]

Conclusion. Previous eye studies were done with equipment that is unsuited in studies that required freedom of movement. The need of modern society places stress on aviation. The needs of man in aviation stresses the requirements of efficient work methods and tools for flying. This gives rise to a requirement of knowledge of man's eye movements while actually conducting an aircraft. Previous equipment was too bulky to make these studies. Motion pictures have provided a new method of eye study recording and have been proved effective by the results achieved from four vital studies.

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[17] How Pilots Use Their Instruments (Dayton, Ohio: U. S. Air Force Air Materiel Command, Engineering Division, /n.d./), film report, approximately thirty minutes, 16mm, black and white, sound.

CHAPTER IV

FILMS ON AVIGATION

The increased dependency on the aircraft for transportation and defense has made it necessary to fly when navigation with visual reference to the ground is not possible.[1] The subject previously discussed dealt with the actual control of the plane by reference to instruments, but not with taking the plane from point to point along a certain path. This chapter is concerned with films that were made on the subject of radio navigation. In keeping with the survey, all available films on this subject were viewed. It is the purpose here to enumerate the pictures and discuss their merit. No attempt is made to consider the films dealing with dead reckoning or celestial navigation for they are influenced by visual references outside the aircraft.

Discussion. Instrument flying is often considered synonymous with radio navigation, owing to the fact that radio has become the primary means of navigation when on instruments. Actually, two distinct techniques are involved. Strictly interpreted, instrument flying is the

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[1] Lesson Plans, U. S. Naval School, All Weather Flight (Corpus Christi, Texas: U. S. Naval Air Station, 1950), p. 57.

art of controlling an airplane by instrument indications. Radio navigation is concerned primarily with directing the airplane to some desired destination. It should be apparent that any flight may be made entirely on instruments and yet not involved radio navigation. Likewise, radio navigation may be practiced, whether on instruments or flying ground contact. As a matter of fact, most air line procedures are based upon radio navigation in either case.[2]

The above distinction between instrument flying and radio navigation is brought out to emphasize the difference in approach that can be followed to achieve a safe and precise technique in either art. Summarized, it may be said that the ability to fly on instruments can best be developed by constant practice in an airplane, preferably the same type of plane, so as to achieve the high degree of visual and physical coordination needed for a precise and safe technique in maneuvering and control. Radio navigation, on the other hand, may be considered largely a mental problem. The ability to visualize the problem at hand by interpreting radio signals into a mental diagram is of

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[2] Colin H. McIntosh, "Instrument Flight," Radio Navigation for Pilots, Part Two (Special edition prepared for Aviation Training Division, Office of the Chief of Naval Operations, U. S. Navy. New York and London: McGraw-Hill Book Company, Inc., 1943), pp. vi-viii.

utmost importance. The development of such skills is primarily a matter of mental training, much of which can be done solely on paper, or, better still, by well directed instruction and practice in the Link Trainer.[3]

The above is important for its definition and explanations. It also points specifically to the role of motion pictures in this subject: "to visualize the problem", and in training, "by well-directed instruction". What better way is there to visualize a problem than making pictures of it? It certainly is not necessary at this point to argue the merits of motion pictures as a means of well directed instruction. Modern educational methods have made it possible to train persons in literally thousands of subjects by making use of both the auditory and visual senses.

Source of information. The material herein is based on four films, for there were only four films uncovered by the survey. These films were located in the "Catalogue of Films Distributed by the Civil Aeronautics Administration", under the subject of "Instrument Flight Control".[4] The

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[3] Loc. cit.

[4] Catalogue of Films Distributed by the Civil Aeronautics Administration (Washington, D. C.: U. S. Department of Commerce, Civil Aeronautics Administration, Office of Aviation Development, January, 1951), p. 12.

films, all made for the Navy, were

(1) Instrument Flight Control - Radio Navigation Part II - Bracketing an Unknown Beam. (MN 1059 y).

(2) Instrument Flight Control - Orientation The 90 Degree Method (MN 1059 z).

(3) Instrument Flight Control - Orientation - The True Fade System (MN 1059 aa).

(4) Instrument Flight Control - Orientation - The Fade Parallel System and Close-In Procedure (MN 1059 ab)[5]

<u>Description of the films</u>. All four films were made in the same manner. They very simply, but very effectively, with a limited amount of live action to add interest, used a diagrammatic construction. A small airplane moved along the presented course of action over a background that represented the face of the earth. All action was portrayed in a manner to make the audience look down on top of the plane as it moved along. Sound effects consisted simply of the signals of the radio beams, while a narrator described the action of the plane and the reason for it. The advantages of animation are its ability to show things inaccessible to the camera, and its graphicness in presenting material which might be uninteresting, incomprehensible, or too impractical to photograph. These advantages were

[5] Civil Aeronautics Administration film library, 5651 West Manchester Boulevard, Los Angeles, California.

applied here to demonstrate something that live action could not.

These four films were very similar in nature of presentation. As a matter of fact, they were identical in presentation and only the differences in the four subjects warranted the separate films. It is generally recognized in aviation circles that the "Fade 90" method of orientation is the most advantageous, and for that reason will be illustrated in order to render an account of the films.

Illustration. An aircraft was depicted as approaching a known radio station. The method of orientation is as follows:

(1) Properly tune and identify the radio navigational station.

(2) Compute by reference to charts the bisector heading of the quadrant signal being received. Notice the time. Time is always an important element for it is extremely easy to become disoriented and misjudge time. A plane, once in a quadrant, can intercept only one of two possible legs which make up the quadrant.

(3) The signal is carefully analyzed while the pilot is flying, for it is his interpretation of the signal that guides him in his search for the center, or cone, of the station.

To better illustrate this, it is wise to diagram the signal of a radio station. See Figure VII. It will be noted that a radio navigation station is comprised of four accurately controlled directional beams. The area between those beams are "quadrants". The quadrant in which the true North meridian falls is designated the "N" quadrant and is marked by the Morse Code signal for an "N", which is a dash-dot (-.). Proceeding clockwise, the remaining three quadrants are marked "A" (dot-dash), "N" and "A". The beam gives a steady signal which is a combination of the "A" and "N" signal. The areas adjacent to the beam is all quadrants are called "twilight areas" and sound both the beam signal and the signal particular to that quadrant (bisignal).

These films assumed the pilot to be in various positions of the station area and proceeded to work out the solutions. As an illustration of how graphic this type of film can be let us assume that the pilot of a plane is in an absolute clear area of the northern quadrant signal. In this case the signal would be an "N". See Figure VIII. As he is inbound, the strength of his signal would gradually build up as he approached the station. The pilot flies a heading equal to the bisector of the area that he is in. Inspection of the beam diagram indicates that as he approaches the center of the station, he is more likely to intercept one of the two legs before he reaches the center

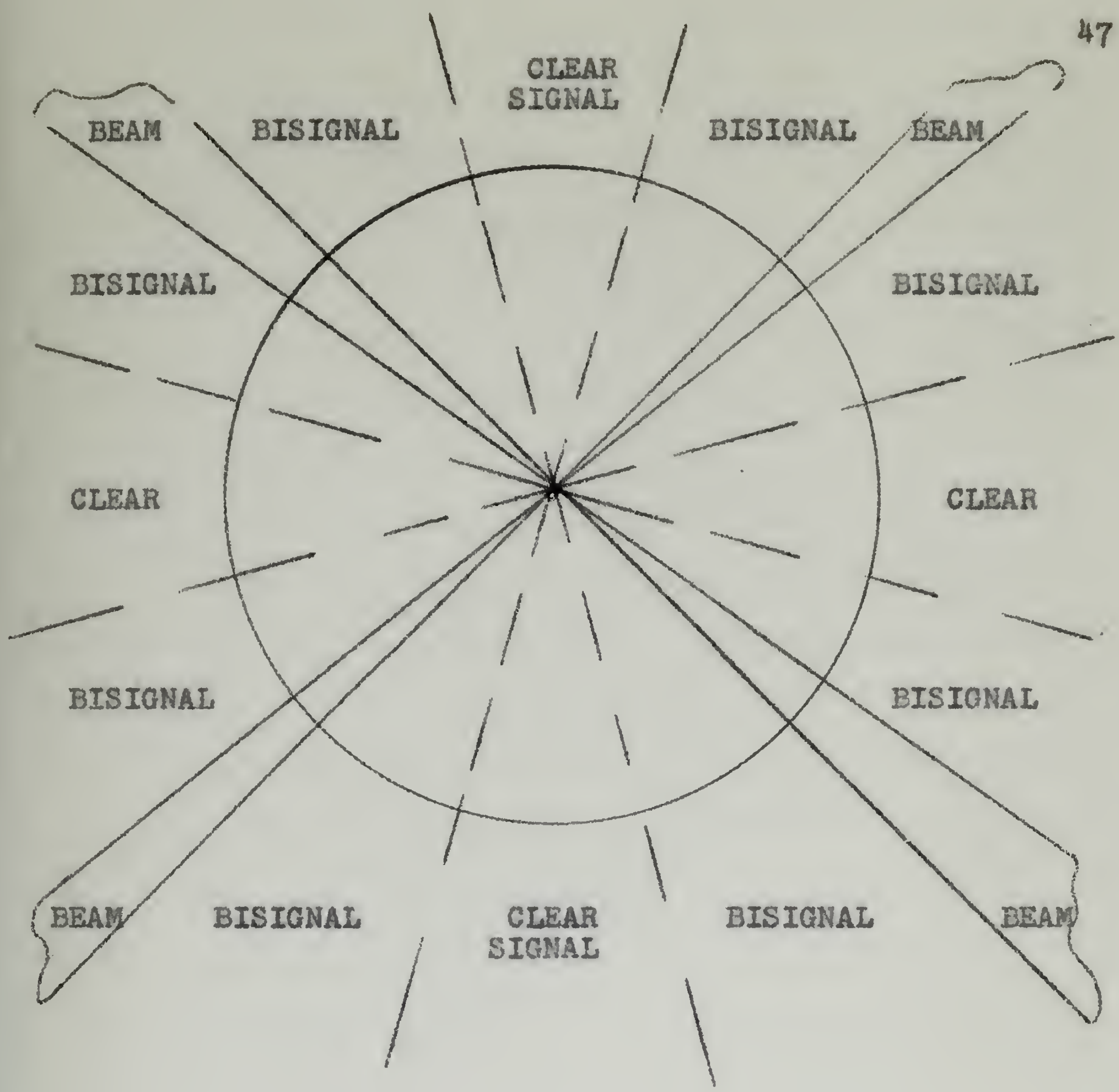


FIGURE VII

DIAGRAM OF THE SIGNALS SENT OUT
BY A NAVIGATIONAL RADIO STATION

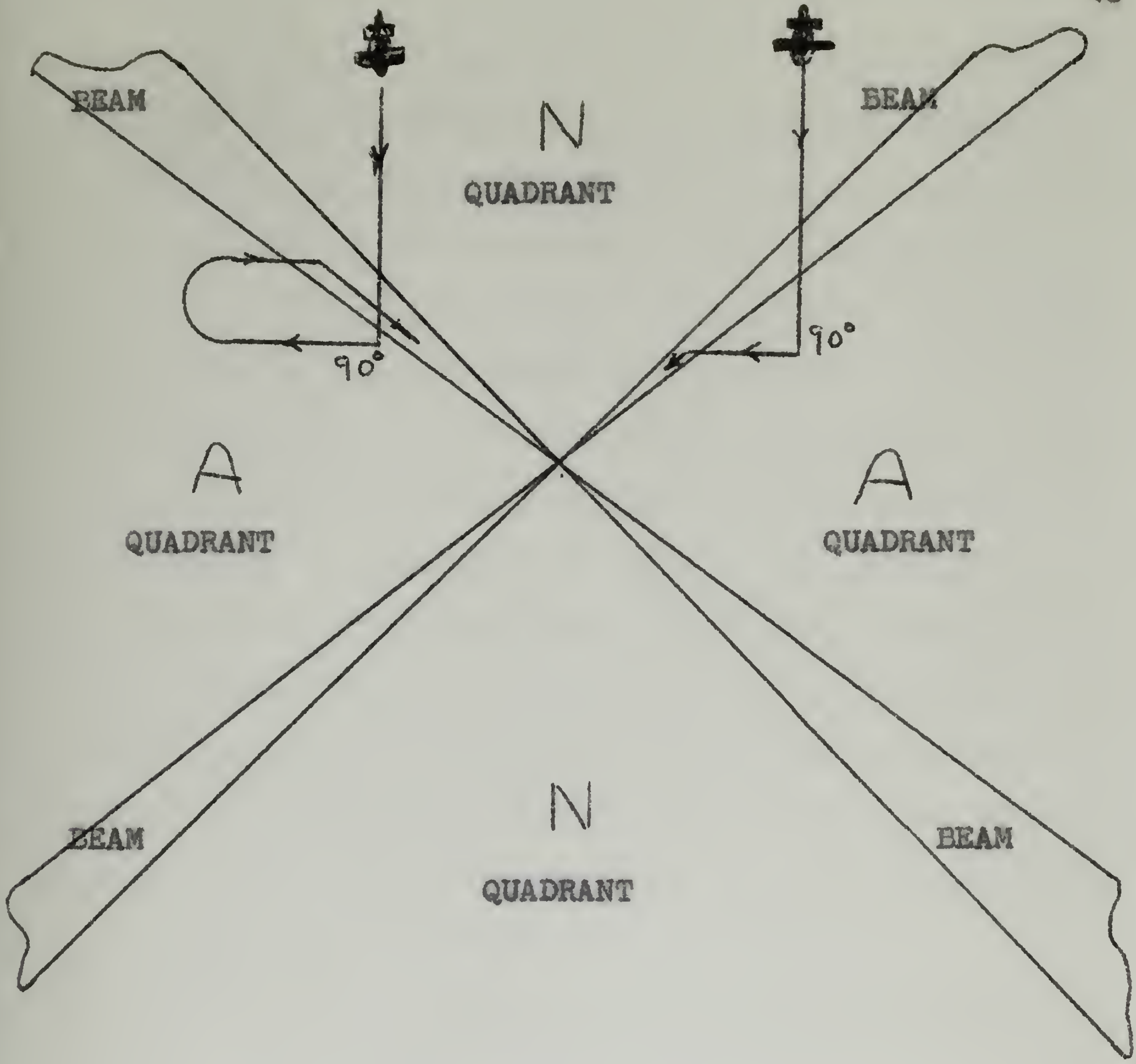
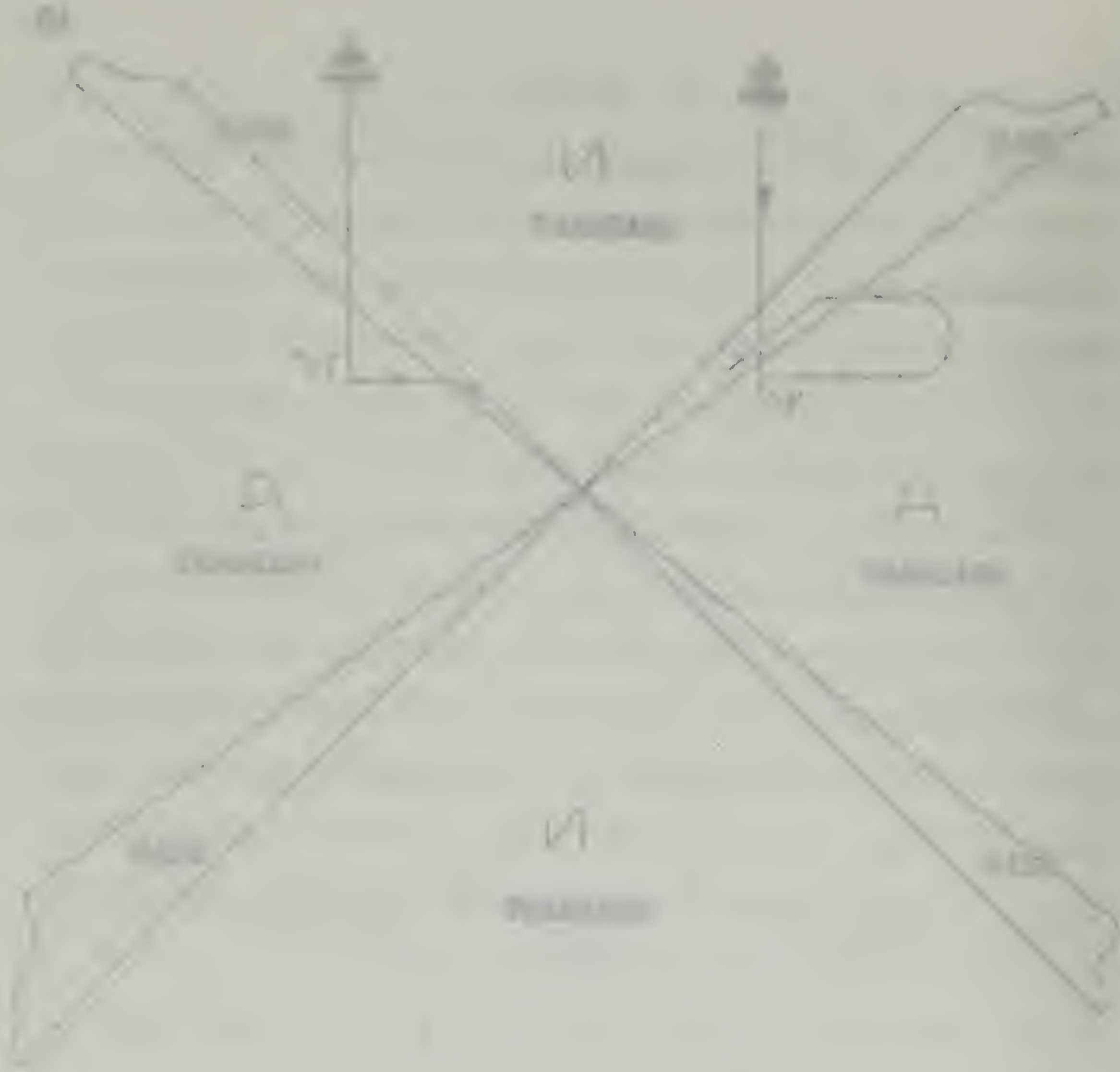


FIGURE VIII

DIAGRAM OF THE NINETY DEGREE METHOD OF ORIENTATION
ONLY THE BEAMS AND QUADRANTS OF THE RADIO SIGNAL ARE SHOWN



of the station. It is the interception of one of these legs that brings into use the 90 degree maneuver for identification. It is necessary to know which beam has been reached. The beam signals sound the same and they have definite courses or headings of their own. In order to follow a course it is imperative to know which one the pilot is receiving. Inspection of the diagram will indicate that if a 90 degree right turn is made after the left hand beam of the diagram is intercepted, the plane flies away from the beam. On the other hand, if the right beam is intercepted and a 90 degree right turn is made, the beam is again intercepted. Thus, a 90 degree right turn identifies the beam. Procedure from here on consists merely of determining wind effect by means of bracketing the beam and taking a heading into the station.

The value of these films fall into two catalogues:

(1) demonstration

(2) teaching methods of visualization.

Man is in an unusual element when he flies and he is not accustomed to being guided by sound alone. Therefore any demonstration on the details of a system will increase his knowledge and confidence.

The other use of the film, teaching visualization, is extremely important, for every solution to this type of problem is a variable as the wind and the particular

location of the station beams. There is a definite need to learn to visualize the plane's motion over the ground in relation to the effects of the winds.

These films were considered helpful and useful in their rendition. Very important is the fact that film standardizes instruction. The same systems must be used by all pilots to insure safety and control. Through their use the instruction can be spread over wider areas where the need is great, but the ability to teach is thin. It is quite conceivable that ground school could be made up mainly of films, while instructors were freed to instruct in the air. Films alone are not the best teaching method, but they greatly assist, and with their use it is possible for men to teach themselves when instructors are not available. Training films will never replace the teacher or actual training or the manual, or textbook. They will, however, aid in training more quickly and more thoroughly. During war time pilots must be inducted and quickly taught new skills. They must be encouraged to enter new and strange environments with confidence in themselves and in their instruments. Research has attempted to estimate the amount of training saved by the use of visual aids. A conservative average seems to be about thirty per cent. Suffice it to say that training aids contribute sufficiently in training men more speedily, more thoroughly and more efficiently.

CHAPTER V

CONFIDENCE IN INSTRUMENTS

This chapter concerns itself with films that could be used to build confidence. The greatest need of instru-flying is sound confidence in one's ability and in one's instruments. Several films that demonstrated the use of various instruments were aids in establishing the confidence of the pilot in his instruments.

A man normally knows of his position or location in his surroundings mainly through sight. His balance and sense of direction is maintained because he has reference to horizontal and vertical landmarks. As long as he stays in familiar environment, or in his own elements he is usually confident. Even in some cases where he is denied light, such as on dark nights, he still maintains his upright position. In the air, man is out of his element and is affected by unfamiliar forces. When he is in the air and in poor weather conditions and his usual reference marks are taken away he loses his balance and direction. A man in the air during bad weather conditions must be taught to trust his instruments over his own sensations. He must have a working knowledge of the instruments and their limitations.

Discussion of films. One film[1] explained the deficiencies of the magnetic compass and the advantages and parts of the gyro compass and how they work. It also checked the gyro compass against the magnetic compass, as well as illustrated the use of the compass as a turn indicator.

A second film[2] described the basic principle of operation of gyroscopic flight instruments. It presented the gyro horizon and its method of response, and demonstrated the typical deflections obtained under various flight conditions.

These films are good aids in teaching the construction and workings of two vital flight instruments, namely, the gyro horizon and the directional gyro. Of all the instruments used, the gyro horizon gives the most realistic indication of the attitude of the plane. The miniature airplane, interpreted with relation to the horizon bar, corresponds at all times to what the pilot would see if he looked at the nose of his plane in relation to the actual horizon. This fact was very clearly

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[1] "The Directional Gyro," The Automatic Pilot (U. S. Army training film MA 494A, Nonclassified, 1942), 10 minutes, 16mm, black and white, sound.

[2] Ibid., MA 494B.

illustrated by picture superimposure of the gyro horizon on the actual horizon as the aircraft was put through various maneuvers.

Instrument indication. The instrument indications rely on the fact that it contains a freely mounted gyroscope which at all times remains in a constant plane relative to the earth. A system of gimbles inside the instrument case supports the gyro, which rotates in a horizontal plane when used as a gyro horizon. As the plane pitches and banks, the instrument case, being fixed to the plane, moves in the same manner, but the gyro inside holds its stable horizontal path. The movement of the instrument case with respect to the gyro is shown on the face of the instrument as movement of the miniature airplane with respect to the horizon bar. They correspond to the movements of the actual airplane with respect to the real horizon.

One disadvantage of the gyro horizon is that the horizon bar moves instead of the miniature plane, and although the reading is true, its motion is not. In other words, as a plane banks to the left, the horizon, either actual or gyro moves in an opposite direction. Thus the action is misleading. This presents confusion to an inexperienced pilot until he learns to interpret the reading.

Films that display the instruments' motion and then show superimposures of the instrument over the actual horizon clearly illustrate proper use and interpretation. This leads to confidence. See Figure IX.

The directional gyro also operates on the principle of the stability of a freely mounted gyroscope. It basically consists of an air-driven gyroscopic wheel, mounted so that it rotates in a vertical plane. Attached to the mounting is a circular scale similar to a compass card. This indicates the headings set into it. See Figure IX.

One disadvantage of the directional gyro is that it wanders off course and has to be reset frequently. Such a trait, unless recognized, is apt to confuse a pilot who has not used the instrument. The film[3] mentioned demonstrates clearly the fact that the gyro compass must be aligned with the magnetic compass, and must be frequently checked for the errors that creep into it constantly. The demonstration, showing the correct use, brings out the advantage of the instrument and illustrates them over their shortcomings. The visual comparison is a measure to increase confidence.

A third film[4] illustrates a comparatively new

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[3] Loc. cit.

[4] Attitude Gyro Indicator (U. S. Navy training film MC 5241. Nonclassified, 1945), 9 minutes, 16mm, black and white, sound.

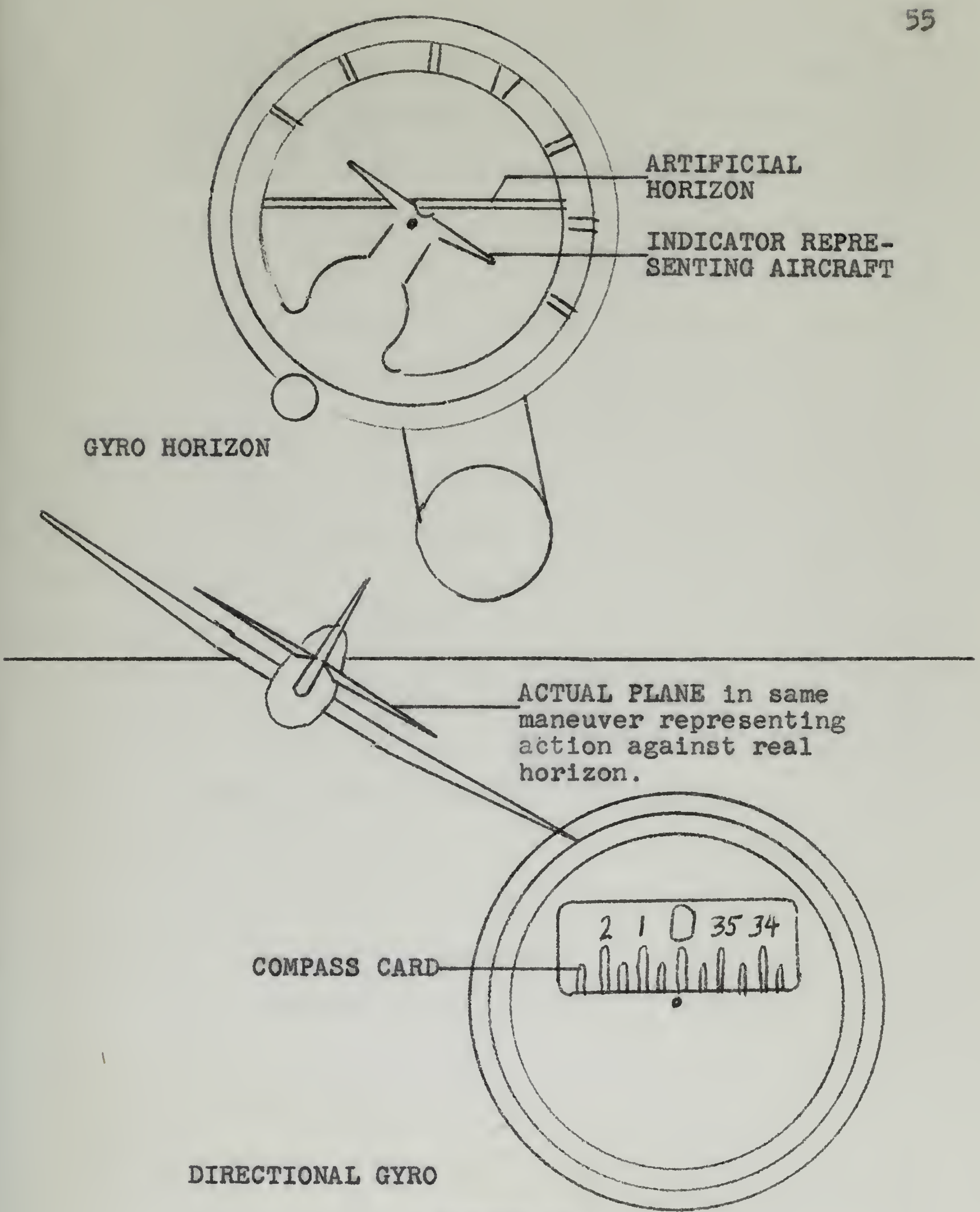

FIGURE IX

GYRO HORIZON AS COMPARED WITH ACTUAL PLANE ACTION
AND GYRO COMPASS OR DIRECTIONAL GYRO

instrument that incorporated the indications of the gyro horizon without the tumbling hazards of the horizon. The gyro horizon is said to have tumbled when it has been put into a position that exceeds the operating limits. After it has tumbled its readings are no longer useful.

This new instrument, called the "attitude gyro indicator", is in its essence, a gyro horizon that does not tumble. The film illustrates its use by moving a mounted unit through all possible directions. The unit was photographed as it was moved about. This film led to the conclusion that a pilot would always have some reference to the horizon regardless of the attitude that his plane was in.

The film clearly illustrates the motion the instruments would go through in the event the plane completed a roll or a loop. It also brought out the coloring of the instruments and depicted the indications at various attitudes. Visual evidence again plays a part in establishing confidence in an instrument.

A fourth film[5] made an actual demonstration of stability as a bid for confidence. The aim of the film was to compare in flight three types of compasses, namely, the magnetic, the gyro, and the new Sperry gyrosyn.

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[5] The Gyrosyn Compass (Great Neck, Long Island, New York: Sperry Gyroscope Company, /n.d./), 16mm, black and white, sound.

Two cameras were used. One was mounted in the clear plexiglass nose section of the plane and rigged to photograph the plane's path over the ground. The second camera was mounted in front of a second instrument panel that was located in the fuselage of the plane. The three compasses were arranged side by side, the panel lighted, and the two cameras were placed on the same electric circuit. The plane was then started on its flight. The nose camera made a constant record of the plane's track, or path over the ground, while the second camera recorded at the same time, the indications and errors of the three compasses. The results from the two cameras were superimposed so that the compass readings were shown for every point on the plane's track. In this manner, it was simple to measure the accuracy of the various units. The film was made to demonstrate the comparative greater stability of the gyrosyn compass and thus increase confidence in its use. The film served its purpose.

The four films mentioned were produced mainly as instructional films for the use of or support of various instruments. However, their presentations were such that could lead a pilot to have confidence in his equipment.

CHAPTER VI

FILMS ON NEW AIDS TO INSTRUMENT FLYING

This chapter is concerned with two films: "Integrated Landing Aids, Parts I and II."[1] They were the only ones available on this subject.

A great deal of work and experimentation has been done to find ways that would enable planes to land during conditions of poor visibility. The great expense of the systems make it prohibitive to immediately erect the various systems at all airports. However, their existence and appearance are of prime importance to air minded people.

"The Integrated Landing Aids" films were made for pilots with the idea of merely presenting basic information. It employed both animation and live action, with a large part of the live action presented in a way to make the audience appear to be the operator. This is one of the fine features of the films. They make no attempt to evaluate any of the systems depicted. They merely present, in the only way possible, an excellent account of how the various systems work and look.

These films, in color, were made at the Landing Aids Experiment Station, Arcata, California. The locale,

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[1] Available at the Civil Aeronautics Administration film library, 5651 West Manchester Boulevard, Los Angeles, California.

notorious for its bad, foggy weather, is an ideal site for working in landing aids. Tests were often conducted in conditions of zero/zero visibility and ceiling.

Four systems of aids were illustrated, namely:

(1) Ground Control Approach (GCA)

(2) Instrument Landing System (ILS)

(3) High Intensity Lights

(4) Fog, Intensive Dispersal of (FIDO)

Ground Control Approach (GCA). The Ground Control Approach system was the most difficult of all to present pictorially. The system requires no extra equipment in the aircraft, though it does demand three sets of radar gear located on the ground at an optimum point to one side near the mid-point of the landing runway. The usual installation is a vehicle that can be moved to any desired point.

The three systems of radar consist of: (1) a search unit that scans an area of three hundred and sixty degrees for approximately thirty miles. This is used to locate or position a plane in relation to the air station. (2) A second unit is a highly directional radar beam that scans an arc of twenty degrees in relation to the center of the runway in use. This is the "Azimuth Beam" and it is used to steer a plane to landing. (3) The third unit is a second highly directional unit that indicates elevation.

This beam is made to conform to the topography and obstructions around the landing site. The interception of the elevation beam and the azimuth beam forms an optimum line of motion called "The Glide Path". The object of GCA is to talk the pilot onto the glide path. This, obviously, is difficult to photograph. However, the voice communication between the operators was informing.

The film presented an operator's view point by means of a camera mounted in the nose section of various types of aircraft. Tests were conducted in conditions of visibility as low as nine hundred feet and ceiling of fifty feet. Covering shots of the plane flying in the fog presented an extremely realistic impression.

<u>The Instrument Landing System (ILS)</u>. The instrument landing system, like GCA, was difficult to present photographically. Animation very aptly demonstrated the principle of the system, which uses two directional radio beams. One beam was localized over the center of the runway and indicated the azimuth. A second beam indicated elevation. These beams are received by special radio equipment aboard the plane and indicated by an instrument called the "Cross "Pointer", the position of the plane in relation to the landing area. Two needles over a center point in the cross pointer indicated the position in relation to the optimum

path of flight. See Figures X, XI, and XII.

Cameras, again mounted in the cockpit to photograph the cross pointer and its needle action and in the nose of the plane to present an unobstructed view, present an ideal indication of the action. This is, again, very desirable from an informational standpoint.

The Instrument Landing System differs from the Ground Control Approach in that the pilot alone controls his flight and position in the Instrument Landing System. In the Ground Control Approach, the pilot is dependent on the radar operators to tell him his position.

The High Intensity Lights. The High Intensity Light methods of approach lend themselves very well to photography. Some of them are even spectacular when photographed at night. The camera is of exceptional value in these systems by virtue of their own need of data recording.

The purpose of the light systems, as in the other systems, is to aid the pilot to land his craft. They lead him to the runway and are in addition to the lights used to mark the runway boundaries. Many combinations of lights have been experimented with, but they all are required to establish for the pilot, by some means of presentation, the factors of elevation and direction. One system, the "Slope Line" lights, does this by means of slanted rows of lights.

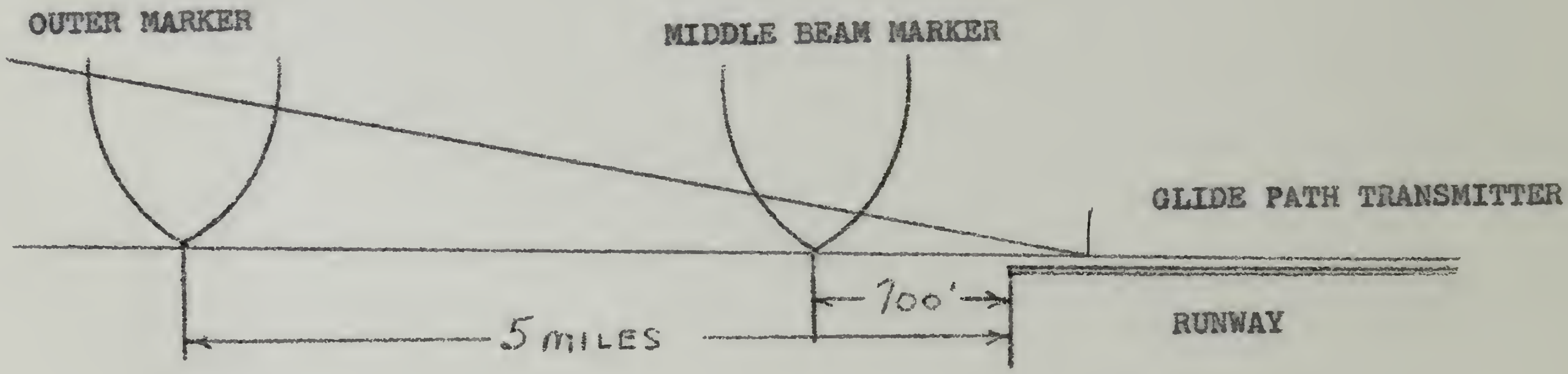

FIGURE X

GLIDE PATH AND MARKER BEACON INSTALLATION

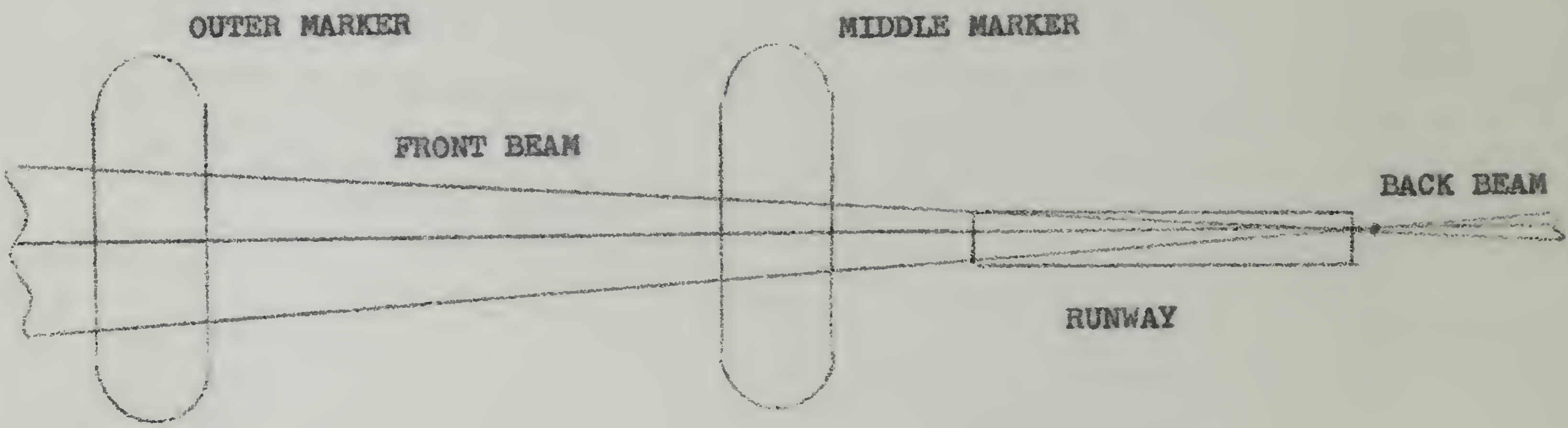

FIGURE XI

RUNWAY LOCALIZER INSTALLATION

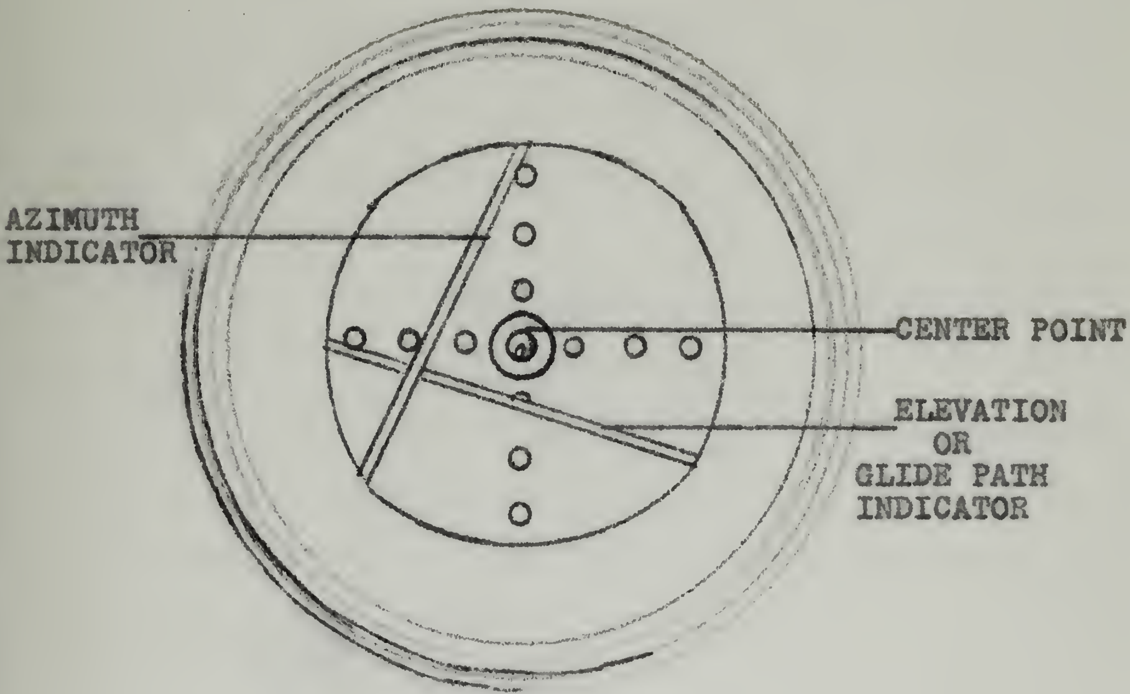

FIGURE XII

CROSS POINTER USED IN INSTRUMENT LANDING SYSTEM

The rows of lights appear as slanting, guiding lines when the pilot is descending properly along their paths. When the craft is improperly aligned the slope lines appear broken and in echelons, thus indicating improper descent. See Figures XIII, XIV, XV, XVI, and XVII.

The camera was used, too, in the evaluation of various light systems. Lights must provide three items of vital information:

(1) the distance out from the runway, called the "X factor";

(2) the center line and the plane's position right or left of it, called the "Y factor";

(3) the altitude required for a safe descent over obstructions, called the "Z factor".

Cameras were mounted in the plane to determine these requirements as well as to exhibit them.

Fog, Intensive Dispersal Of (FIDO). FIDO is used together with a high intensity light system. It is a thermal system that evaporates water vapor and raises the ceiling. This system grew out of the last war from a meager beginning of gasoline in a trench to the present system of jet sprays and automatic ignitors that can be turned on when a plane is only two minutes away from its touch down point. The terrific heat causes the ceiling in the

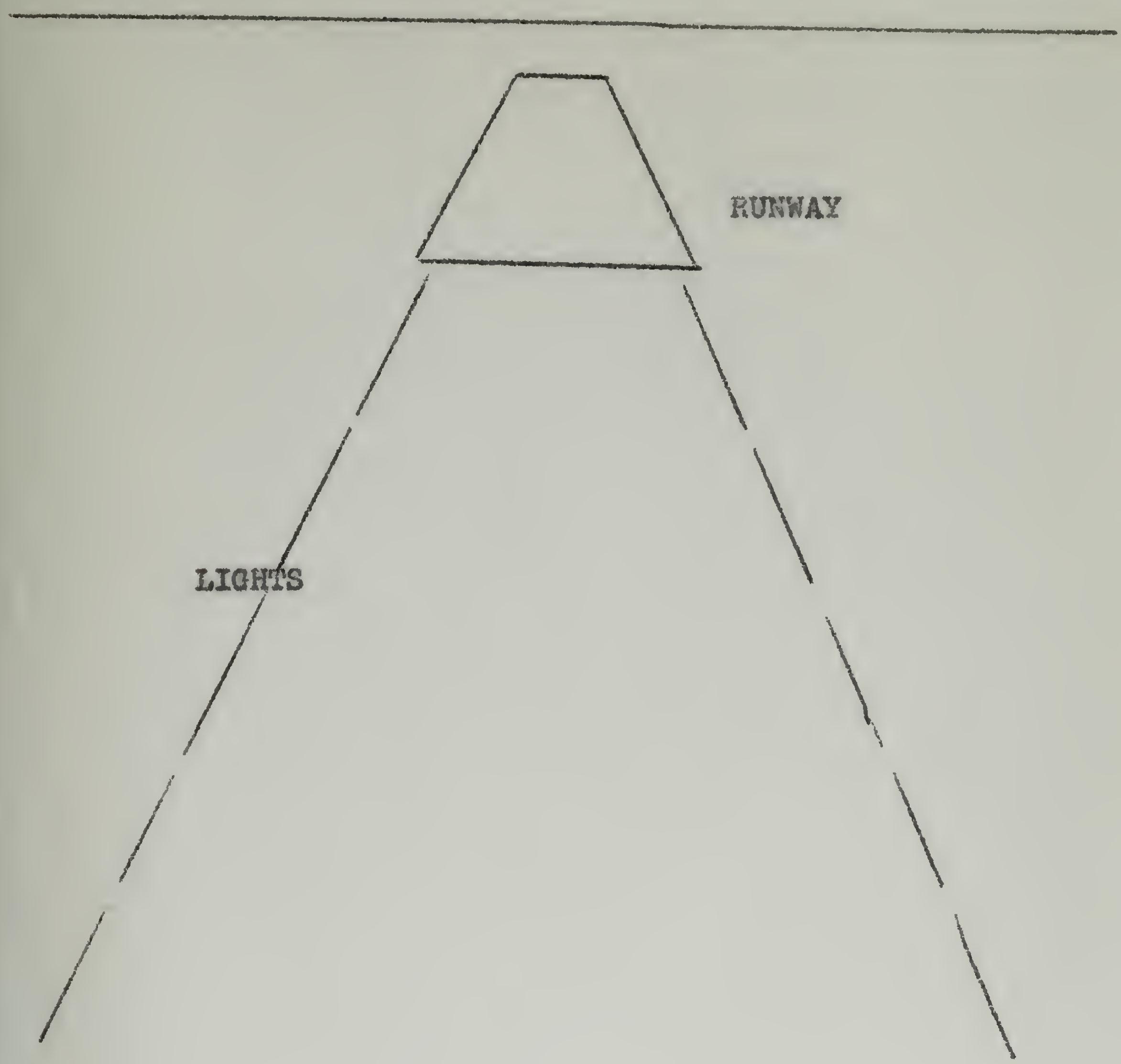

FIGURE XIII

HIGH INTENSITY LIGHT (SLOPE LINE)
THE PLANE IS CORRECT. ON CENTERLINE, ON GLIDE PATH
BOTH ROWS OF LIGHTS FORM STRAIGHT LINES

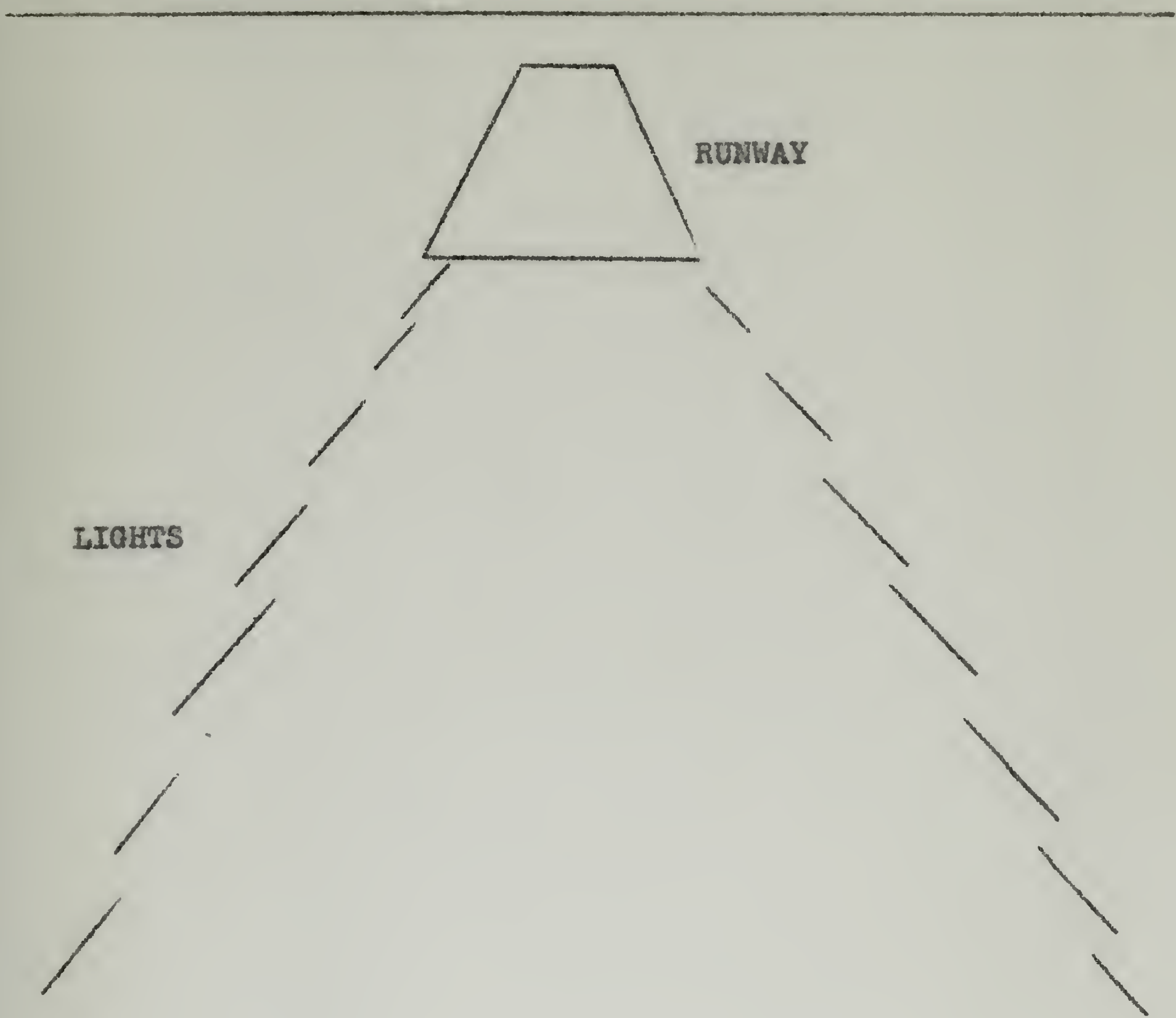

FIGURE XIV

HIGH INTENSITY LIGHTS (SLOPE LINE)
THE PLANE IS HIGH BUT ON THE CENTERLINE
LIGHTS BREAK THEIR STRAIGHT LINE AND POINT DOWN. FLY DOWN

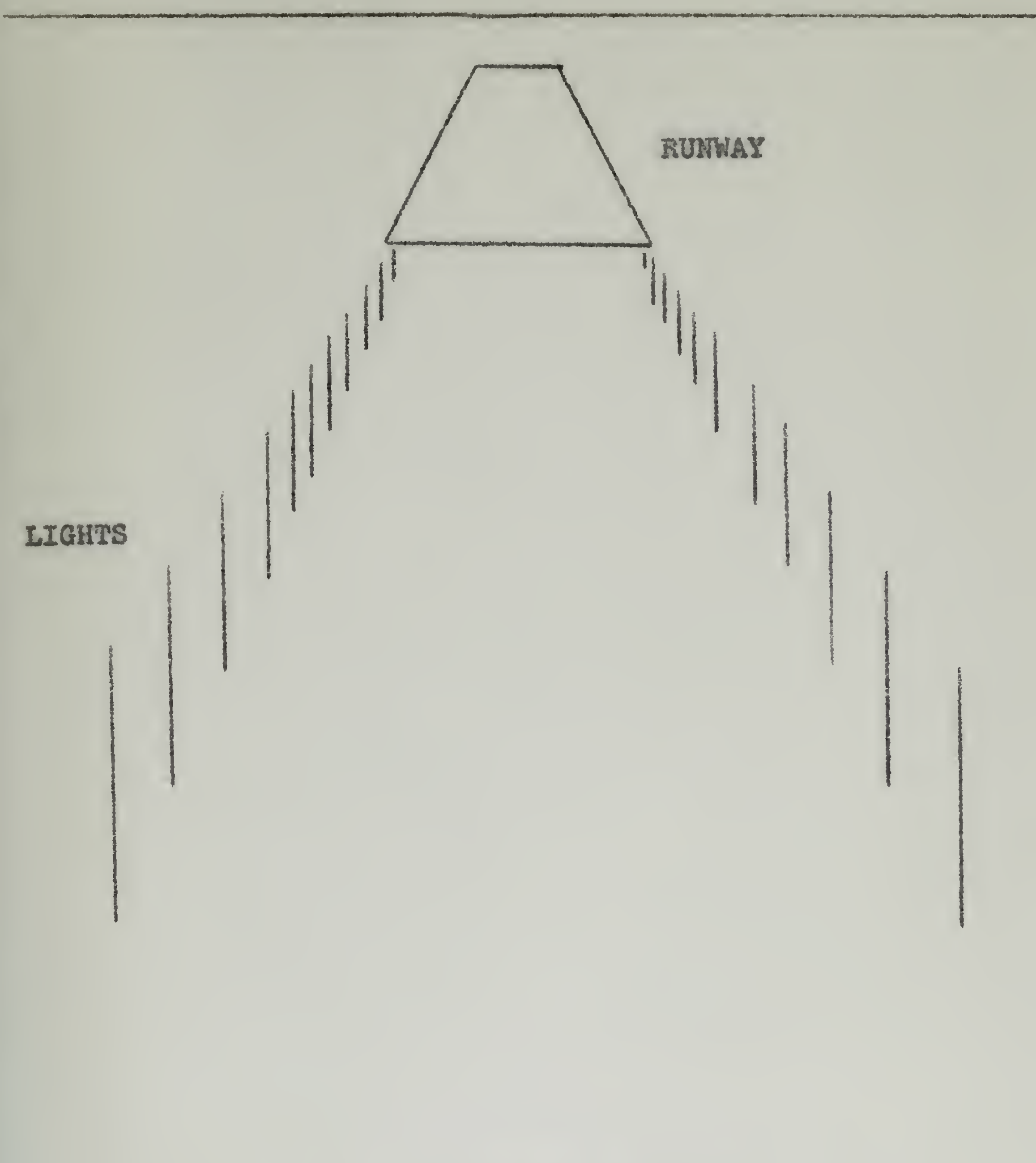

FIGURE XV

HIGH INTENSITY LIGHTS (SLOPE LINE)
PLANE IS LOW BUT ON CENTERLINE
LIGHTS BREAK STRAIGHT LINE AND POINT UP
SO GAIN ALTITUDE

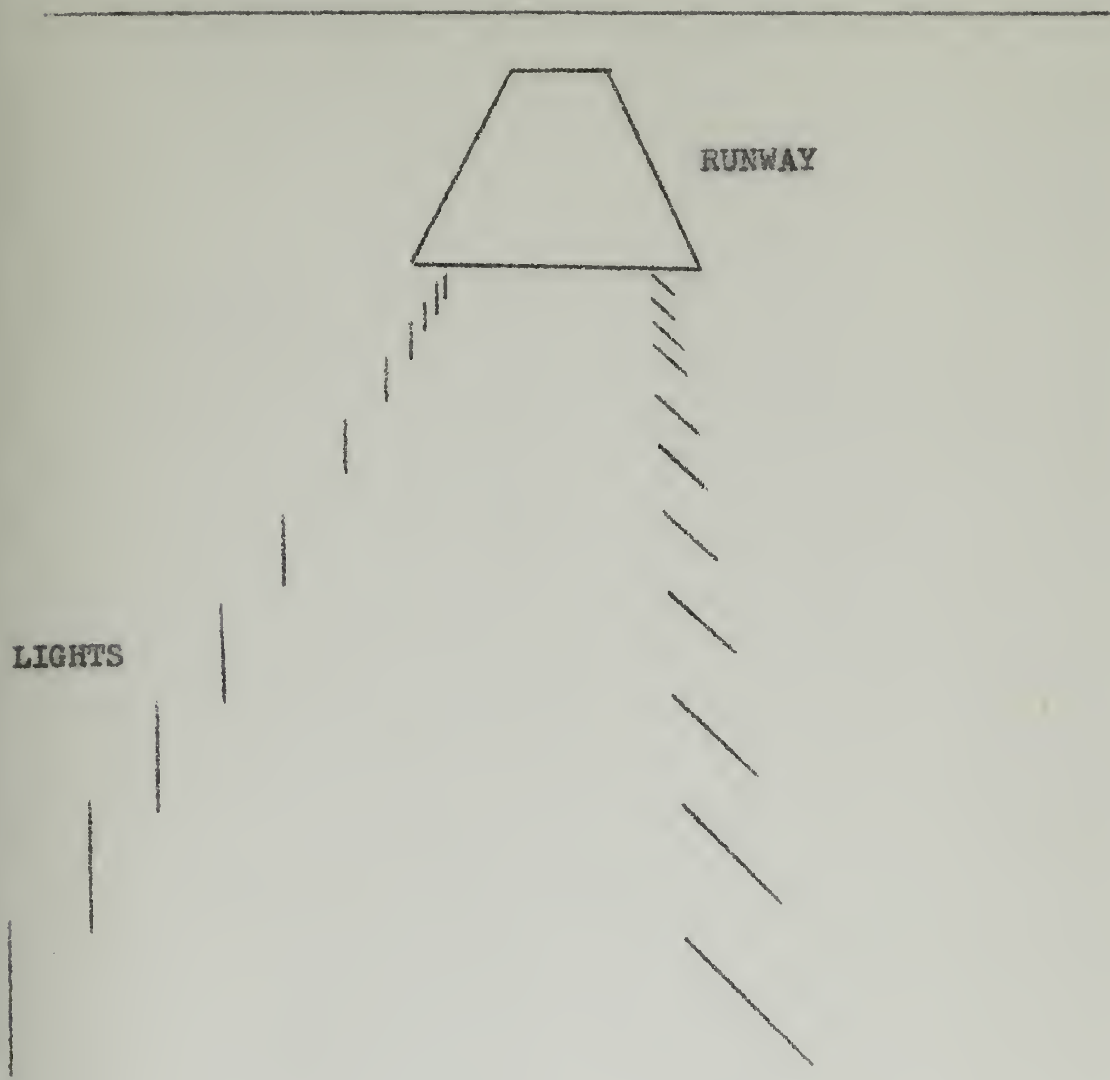

FIGURE XVI

HIGH INTENSITY LIGHTS (SLOPE LINE)
PLANE IS ON GLIDEPATH BUT IS RIGHT OF THE CENTERLINE
LIGHTS POINT LEFT SO FLY LEFT

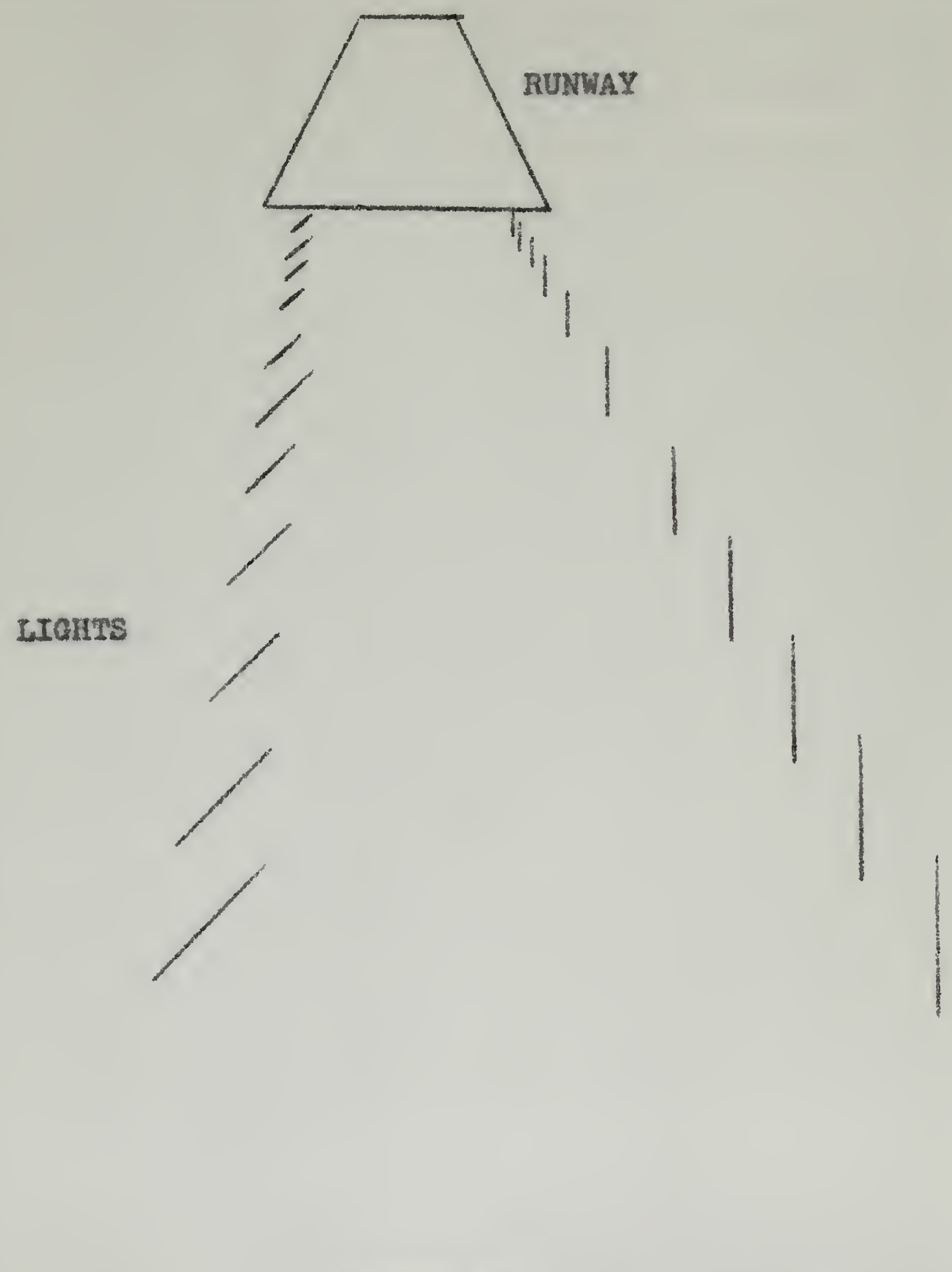

FIGURE XVII

HIGH INTENSITY LIGHTS (SLOPE LINE)
PLANE IS ON THE GLIDEPATH BUT IS TO THE LEFT OF CENTERLINE
THE LIGHTS POINT RIGHT SO FLY RIGHT TO BE PROPERLY LINED

immediate area to lift and this permits the pilot to see his landing area.

Motion pictures in this case presented evidence of the usefulness of FIDO. FIDO made possible a visible touch down under conditions that planes usually do not attempt to land under.

Evidence of interest. The interest in films of this type and the pictorial data they present is growing. A picture in this catalogue was presented during a symposium on all-weather flying at the nineteenth annual meeting of the Institute of the Aeronautical Sciences in New York City in February, 1951. The film was made by the Sperry Gyroscope Company and the Landing Aids Experiment Station, at Arcata, California. This film was not available at the writing of this survey, but information about it is quoted.

> . . . Over fifty scenes were included of actual approaches in bad weather. Some were made with visibilities as low as 150 feet and ceiling zero. So impressive were some of the scenes that the audience occasionally tried to help fly the plane by use of "body English" and exclamations. These pictures are blunt, unmistakable proof of the good and bad points of various configurations.
>
> . . . .
>
> For years, airports with left hand approach light installations have had runway lights knocked down on the right side of the runway. Until recently there was no explanation for this, nor was the significance understood. The answer, an optical illusion, is clearly evident in the film. . . . These scenes clearly indicate the need for such markings /runway centerline, threshold

markings/ to provide contrast and to maintain alignment throughout the landing roll.

. . . By a clever bit of photography, the Sperry cameramen were able to show simultaneously the pilot's eyes and cockpit instruments, as well as the view of the plane. . . .

. . . .

Many other interesting facts are shown in the film. . . . Everyone active in this field should see the film. It gives one the feeling of actually being in the pilot's seat and one can understand his problem and see the solution in indisputable pictures.[2]

Conclusion. Motion pictures lend themselves well as a means of demonstrating and evaluation of visual aids to aviation. Through their use information was collected and disseminated, in a limited quantity, to interested parties. Their point of view was realistic and valuable in that they were used to place the audience in the position of the operator.

---

[2] R. C. (Ace) Robson, "Cockpit Viewpoint," Aviation Week, 54:48, February 19, 1951.

CHAPTER VII

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The aims of this chapter are to present briefly the findings of the survey, the conclusions drawn from it and make recommendations. This study accepted the premise that motion pictures are an excellent training aid, and merely considered the extent that they had been used in a specific field. Although the method of study was directed at a variety of sources of possible users or makers of films, it was forced to narrow itself to the agencies of the government, mainly the military forces. This was imperative because of the cost involved and the number of people likely to use or need such films.

Photography lends itself very well to aeronautics, and is directly related in many aspects of the science and the industry. Many fine and indispensable films have been made on various phases of aviation and on subjects related and important to aviation. However, the films that this thesis concerned itself with were very few in number. Those that existed were made by the United States Government, mainly for the military forces. They were, generally speaking, out of date and had not kept up with the advances in aviation.

Conclusions. This survey indicated that

psychologists have found motion pictures to be the only method of recording that would satisfactorily record the eye movement of pilots during the actual operation of their planes under instrument conditions. This is significant for eye studies will influence the future designs of instruments and instrument panels.

One phase of instrument flying is not adaptable to motion pictures. That is the actual control of the craft. This is a skill that is developed only through experience and practice. Some of the greatest and most important factors considered are confidence in instruments, practice, experience, and belief in one's ability. Films can and do teach the construction of instruments and they are indispensable as a means of imparting foundation knowledge. But, the only way a man is going to learn to fly instruments is to fly them.

Avigation is adaptable as a filmic subject because of the advantages of demonstration. The principal means of conducting a plane, at present, between points is the low frequency radio range. The information sent by the range is only an audible code signal. This offers a problem, for man is not normally or usually guided by sound alone. Motion pictures ably demonstrate the use of these ranges and teach the novice methods of visualizations.

New systems of lights that influence landings or the

handling of aircraft on the ground are ideally suited to photography. Films not only present the information desired but depict it from a view that simulates the pilot's. This is desirable and important since it enables the audience to achieve the same "feel" that a pilot does.

Recommendations. It is recommended that motion pictures be used to teach scan patterns. The most important single item in instrument flight is the pattern of constant use of all instruments. Just as films have been used to teach reading habits, they can be used to develop scan patterns.

Cameras could be used to aid student pilots to learn to visualize their radio ranges. The two camera system that the Sperry people employed to demonstrate their gyrosyn compass could be used to record the path of a plane over the ground in relation to audio signals and instrument attitudes.

Separate films could be made on basic air work to demonstrate correct use of instruments. These films could define the scan pattern and the proper procedure. Thus they could increase the availability of instruction and enable pilots who have at one time or another flown instruments to refresh themselves. This effectively increases available instruction.

Films could be made of the various holding patterns. Especially those airports that are subject to a great deal of traffic and which have their own local patterns should produce instruction films that would be available to anyone in their area.

Films demonstrating patterns and techniques should be as simple as possible to eliminate the high cost that discourages production and the renewal of old and out-of-date films.

B I B L I O G R A P H Y

BIBLIOGRAPHY

A. PERIODICAL LITERATURE

Jasper, Herbert H., and Robert Y. Walker, "The Iowa Eye Movement Camera," Science, 74:291, September 18, 1931.

Robson, R. C. (Ace), "Cockpit Viewpoint," Aviation Week, 54:48, February 19, 1951.

B. PARTS OF SERIES

Catalogue of Films, Distributed by the Civil Aeronautics Administration. Washington, D. C.: U. S. Department of Commerce, Civil Aeronautics Administration, Office of Aviation Development, January, 1951. 35 pp.

C. PUBLICATIONS OF LEARNED ORGANIZATIONS

Instrument Flight Procedures, U. S. Naval Schools, All Weather Flight. Corpus Christi, Texas: U. S. Naval Air Station, 1950. 50 pp.

Jones, Captain Richard E., First Lieutenant John L. Milton, and Paul M. Fitts, Ph.D., Eye Fixations of Aircraft Pilots, I, A Review of Prior Eye Movement Studies and A Description of a Technique for Recording the Frequency, Duration and Sequence of Eye Fixations During Instrument Flight. U. S. Air Force Technical Report No. 5837. Dayton, Ohio: U. S. Air Force Air Materiel Command, Wright-Patterson Air Force Base, September, 1949. 27 pp.

________, Eye Fixations of Aircraft Pilots, II, Frequency, Duration and Sequence of Fixations when Flying the USAF Instrument Low Approach System (ILAS). U. S. Air Force Technical Report No. 5839. Dayton, Ohio: U. S. Air Force Air Materiel Command, Wright-Patterson Air Force Base, October, 1949. 20 pp.

________, Eye Fixations of Aircraft Pilots, III, Frequency, Duration and Sequence of Fixations when Flying Air Force Ground Controlled Approach System (GCA). U. S. Air Force Technical Report No. 5967. Dayton, Ohio: U. S. Air Force Air Materiel Command, Wright-Patterson Air Force Base, February, 1950. 22 pp.

Jones, Captain Richard E., First Lieutenant John L. Milton, and Paul M. Fitts, Ph.D., Eye Fixations of Aircraft Pilots, IV, Frequency, Duration and Sequence of Fixation During Routine Instrument Flight. U. S. Air Force Technical Report No. 5975. Dayton, Ohio: U. S. Air Force Air Materiel Command, Wright-Patterson Air Force Base, March, 1950. 30 pp.

Lessons Plans, U. S. Naval Schools, All Weather Flight. Corpus Christi, Texas: U. S. Naval Air Station, 1950. 239 pp.

MacFarland, Ross A., Alfred Holway, and Leo M. Hurvich, Studies of Visual Fatigue. Cambridge, Massachusetts: Harvard University, Graduate School of Business Administration, April, 1942. 255 pp.

McIntosh, Colin H., "Instrument Flight," Radio Navigation for Pilots, Part Two. Special Edition Prepared for the Aviation Training Division, Office of the Chief of Naval Operations, U. S. Navy. New York and London: McGraw-Hill Book Company, Inc., 1943. 171 pp.

Tinker, Miles A., "A Photographic Study of Eye Movements in Reading Formulae." Carl Murchison, editor, Genetic Psychology Monographs, Vol. 3. Worchester, Massachusetts: Clark University Press, January-June, 1928. P. 81.

D. FILMS

Attitude Gyro Indicator, U. S. Navy Training Film MC 5241. Nonclassified, 1945. 9 minutes, 16mm, black and white, sound.

"Bracketing an Unknown Beam," Instrument Flight Control, Part III, U. S. Navy Training Film, MN 1059 y. Nonclassified, 1945. 9 minutes, 16mm, black and white, sound.

"The Directional Gyro," The Automatic Pilot, U. S. Army Training Film MA 494A. Nonclassified, 1942. 10 minutes, 16mm, black and white, sound.

"Fade Parallel System and Close in Procedure," Instrument Flight Procedure - Orientation, U. S. Navy Training Film MN 1059 AB. Nonclassified, 1945. 10 minutes,

16mm, black and white, sound.

Flight Through Instruments, U. S. Navy Training Film. NOT DISTRIBUTED at the time of this writing.

"Gyro Horizon, The," The Automatic Pilot, U. S. Army Training Film MA 494B. Nonclassified, 1942. 10 minutes, 16mm, black and white, sound.

The Gyrosyn Compass. Great Neck, Long Island, New York: Sperry Gyroscope Company, /n.d./. 16mm, black and white, sound.

How Pilots Use Their Instruments. Film Report, U. S. Air Force Air Materiel Command, Engineering Division. Approximately 30 minutes, 16mm, black and white, sound.

24 August 1951

From: LT William E. STEPHENS, Jr., 354810/1310, U. S. Navy.
To : Superintendent of U. S. Naval Postgraduate School.
Via : Professor of Naval Science, University of Southern California.

Subj: Thesis for degree of Master of Arts; submission of copies.

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